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The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Contents

	PAGE
Adult Education	367
The Arms Commission's Report	367
Phosphorus in Alloy Steels	368
Notes from the Branches	368
Publication Received	368
Correspondence	368
B.C.I.R.A. Annual Meeting and Luncheon	369
Soundness in Iron Castings	371
Steel Moulding Materials	372
Some Factors Influencing the Production of Sound Castings	373
Second Report of the Steel Castings Research Committee	377
Book Review	379
Impact Tests	379
Sheffield and East Midlands Foundrymen Forgather	380
The Week's News in Brief	382
Trade Talk	382
Personal	382
Obituary	382
Contracts Open	382
New Companies	382
Company Reports	382
Forthcoming Events	332
Raw Material Markets	384

Adult Education

At a recent committee meeting held at the City and Guilds of London Institute, we were handed a number of brochures relative to the Sheffield Trades Technical Societies. These disclose an amazing activity in the direction of providing educational facilities for the craftsman, who has passed the stage whereat, in general, systematic study would appeal. Amongst these activities there is a Foundry Trades Technical Society and for its members there are two separate courses each consisting of twenty lectures. One of these covers modern foundry practice and the other, calculations and drawings. Unlike most of the other societies and their associated classes, the Foundry Society enters a number of its members for the City and Guilds examination, and herein lies a basic error. For the other trades the adult student takes notes, and at the end of the session files them with the lecturer, and if satisfactory is rewarded by the presentation of a certificate stating clearly that the student has attended regularly and kept notes. This certificate is encased something after the method one uses for a railway season ticket in a pocket wallet. This we deem a praiseworthy system. For persons, be they young or old, the normal educational courses should be followed as laid down in the syllabus of the examining body. Once the notions of adult education and craft certification are separated, it leaves the field clear for a proper study of Sheffield's extraordinary activity in this direction. We rightly use the word extraordinary for there are about 1,250 members, about half of whom attended a series of special lectures arranged for them, whilst there is still a demand for further subjects to be included. There are also arranged a number of works visits. The secretary, Mr. W. H. Bolton, is obviously an enthusiastic supporter of this type of work and would consider invitations to lecture on this activity in other centres. The fundamental system, as we see it, is to give an added interest in their work to craftsmen who have not had an opportunity to study the scientific side of their craft during adolescence. Reverting to the certification aspect, the form used in Sheffield has much to commend it, but if a craftsman requires a national endorsement to such work then, without equivocation, he must conform to the principles arrived at only after intense and mature consideration by a national committee. Any request for an orientation of such principles should be, in the interests of the candidate himself, very decidedly discouraged.

The Arms Commission's Report

Circumstances have so changed since the Royal Commission on the Private Manufacture of, and Trading in, Arms was appointed that even those who most pressed for it, those who were opposed to private manufacture, scarcely expected to find private manufacture denounced. We need not concern ourselves with the suggestion that armaments should be limited by international agreement. At present such agreement is scarcely to be hoped for. The Government of this and every other country is in fact re-arming as speedily as possible, and since if war came the demand would increase enormously, the problem to be considered is not whether the private manufacture of arms could be suppressed, but how the industrial capacity available can be best placed at the Government's disposal. The issue is purely practical. The Report says bluntly that in time of war industrial resources would require to be conscripted, and that all of our industrial resources would require to be mobilised. That applies, of course, not merely to what are normally regarded as armament firms but to all producers, because in time of war not merely the production of arms, but of food, clothing, power, everything that comprises the necessities in an industrial civilisation, would be needed. It applies, for instance, to all foundries, for whatever may or may not be said of the industry it cannot be classed as one of the luxury trades. To nationalise the armaments industry really means, therefore, the nationalisation of all the industries of the country, which is quite out of the question.

The real issue, however, is that no Government, especially in this country, could afford to ignore the possibilities of development from private firms and individuals. Genius and foresight cannot be confined within the bounds of a government department. On the other hand, the probabilities are that such departments are less likely to be original than those outside. Generally there will be agreement with the restrictions suggested in the Report, but on the main argument no case whatever has been made out for the restriction of private manufacture. There is, however, strong support in the Report for the establishment of an equivalent to the Ministry of Munitions to prepare plans, and to encourage research and to develop costing systems.

Phosphorus in Alloy Steels

The First Report of the Alloy Steels Research Committee (Special Report No. 14), published by the Iron and Steel Institute for the Autumn Meeting held in Düsseldorf recently, contains a section by PROF. J. H. ANDREW and MR. D. SWARUP on "The Influence of Phosphorus on the Tensile and Shock-Resisting Properties of Certain Alloy Steels." We append some of the authors' conclusions.

It is perhaps unwise to draw any fundamental conclusions from series of steels differing so widely in their compositions. Notwithstanding this, the experimental results clearly indicate certain features which lend themselves to the formation of certain ideas.

It has been shown in the Paper that, provided the carbon content be not greater than 0.15 per cent., steels containing as much as 0.15 per cent. of phosphorus can, by the addition of small amounts of alloying elements, be so treated as to give a material possessing not only excellent tensile properties, but a material with a high impact value and increased resistance to corrosion. To cite an example, Steel B12, containing 0.17 per cent. C, 0.54 per cent. Mn, 0.16 per cent. Si, 0.54 per cent. Cu, 0.44 per cent. Cr, 0.2 per cent. Al, with 0.159 per cent. P, gave on normalising from 860 deg. C. a yield point of 26.8 tons, a maximum stress of 37.6 tons, an elongation of 33 per cent., a reduction of area of 63 per cent., with an impact value of 103. When compared with a steel of similar analysis, but containing neither chromium, copper nor aluminium (B_2) which gave 26 tons yield, 33.5 tons maximum stress, 32 per cent. elongation, 53 per cent. reduction of area, and an Izod impact value of 59 ft.-lbs., it will be realised that whilst the added alloying elements Cu and Cr do not seriously increase the tensile properties, they do enhance very greatly the shock-resisting value of such steels. Further, if these tests are compared with those of a steel, also of similar composition, but having a normal phosphorus content, which gave a yield of 17.6 tons per sq. in. with a maximum stress of 27.5 tons per sq. in., an elongation of 36 per cent., a reduction of area of 62 per cent., and an Izod impact value of 99 ft.-lbs., it will be realised that steels containing a reasonably high content of phosphorus may be used profitably where higher tensile properties are required.

The realisation of the maximum effect of the various alloying elements depends on their combination, as is the case with most alloy steels where one alloy enhances the effect of the other. The general effect of chromium is markedly to improve static and impact ductility without a striking increase of strength. The effect of nickel is markedly to increase yield and maximum strength with loss both in static and impact ductility, and copper occupies a position intermediate between these two elements, increasing the strength without considerable loss in static and impact toughness.

Further, the few experiments which have been carried out suggest that, provided an addition of 0.2 per cent. of aluminium is made, such steels will suffer neither from quench-age-embrittlement nor from temper brittleness.

It has also been shown that many of these high-phosphorus steels possess sufficient ductility to allow of them being rolled into sheets, and on account of their corrosion-resisting properties, might be usefully employed when increased resistance to atmospheric corrosion is desired. Much has been brought to light with regard to the theoretical aspect. It is not so much that the investigation has given rise to any definite new theories, but rather that it has pointed the way to future research, and has provided ideas and views that might well be entertained and given due consideration. In the first place, it would appear from the microstructures of certain of the pure phosphorus alloys, and alloys containing in addition copper, that there is definite evidence of two solid solutions.

As phosphorus is known to retain the δ state and copper to act with the reverse tendency, it seems obvious to draw the conclusion that these two solutions are rich in phosphorus and copper, respectively. Further, it has been shown that when the phosphorus is in solution in a steel in distinction to being in the form of a eutectoid constituent, in solution in an acid by means of electrolysis the soluble phosphorus is evolved as gas, whilst the eutectoid remains in the residue.

It is clearly shown that when the phosphorus is in solution the impact is low, relatively to when the phosphorus exists as a eutectoid.

Experimental evidence suggests that the combined effect of copper and chromium is so to saturate the δ or γ phases as to cause the phosphorus to associate itself in some way with the carbide of iron, and be precipitated along with it at the eutectoid temperature. The phosphide, within limits, associated with the sorbite in a finely-divided state, would therefore be a strengthening rather than an embrittling agent. Aluminium will affect these steels in the same way as it appears to do all steels; it serves to refine the grain size, and at the same time to increase the dispersion of the eutectoid constituents.

It has been remarked that the normalising temperature of aluminium-free phosphorus steels is very critical, particularly when the carbon content is rather high.

From the standpoint of atmospheric corrosion, these steels are interesting in that the rust coating is extremely continuous, coherent, and exists as a fine deposit tending to protect the underlying metal.

Notes from the Branches

East Anglian Section.—A meeting was held last Thursday night at the Central Library, Ipswich. Mr. L. Tibbenham presided, and Mr. T. Makemson, the Secretary of the Institute, repeated his lecture based on notes taken during his visit to various foundries in the United States of America, and illustrated his remarks by lantern slides. The discussion which followed centred around specialised foundry plant and methods of moulding.

Colonel C. Portway, supported by Mr. J. L. Francis, proposed a vote of thanks to Mr. Makemson, which was carried unanimously.

Joint Meeting of the Iron and Steel Institute, the Sheffield Society of Engineers and Metallurgists, and the Sheffield Metallurgical Association

A joint meeting will be held on November 16, at the Mappin Hall, the University Applied Science Department, Sheffield, from 3.0 to 5.30 p.m. and 7.30 to 10.0 p.m. The chair will be taken at the afternoon session by Prof. J. H. Andrew (President, Sheffield Metallurgical Association), and at the evening session by Mr. A. J. Grant (President, Sheffield Society of Engineers and Metallurgists). The following Papers will be discussed :—At the afternoon session : (1) "Second Report of the Steel Castings Research Committee," by a Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation, and (2) "The Practical Importance of the Damping Capacity of Metals, especially Steels," by Dr. O. Föppl. (Prof. Bacon has kindly consented to introduce this Paper and to deal with the discussion.) At the evening session : (1) "Controlled Grain Size in Steel," by Dr. T. Swinden and Mr. G. R. Bolsover, and (2) "First Report of the Alloy Steels Research Committee" by a Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation.

Publication Received

Aluminium in Motor Car Design. Published by the British Aluminium Company, Limited, Adelaide House, King William Street, London, E.C.4.

An explanatory sub-title to this publication explains that the brochure is "A short study of the double rôle of aluminium in motor-car design. Its possibilities for weight reduction and as a means for increasing power output." Whilst the second phrase must obviously be the declared ambition of every designer, we are not so sure about the first. There is an early realisation that all car manufacturers cannot command a run of 25,000 cars of one type and this inability can be commercialised by a more rapid adaptation to fashion. Herein enters aluminium as it can be readily fabricated without undue increase in costs.

The book, which is bound by means of a red celluloid tube, ingeniously cut in $\frac{3}{16}$ in. rings in the interior to take loose leaves, is divided into a number of sections. The first section deals with road performance, but our readers will be (as manufacturers) more interested in the second, which treats of the use of light alloys in engines. The old controversy of aluminium *versus* cast iron for crankcases is raised and Mr. L. H. Pomeroy is quoted as giving the relative costs as £3 15s. for iron as against £4 2s. 6d. for aluminium ones which yield a 50 per cent. saving in weight. Aluminium pistons are fully dealt with and some useful points are given as to design. The next item of interest is cylinder heads in which all the usual alloys normally used are reviewed.

Section 3 draws one's attention to the use of aluminium alloys in the chassis, wherein the subjects of axle and transmission are covered. The next section deals with the coachwork and is more concerned with extruded sections and sheets than with castings, whilst Section 5 makes a summary of the principal points. We attach so much importance to this brochure, that we state without equivocation that it should be studied very carefully by every light-alloy foundry executive.

Correspondence

[*We accept no responsibility for the statements made or opinions expressed by our correspondents.*]

Design of Sheet and Cast Iron Parts for Vitreous Enamelling

To the Editor of THE FOUNDRY TRADE JOURNAL.

DEAR SIR,—I must thank Mr. J. H. Coupe for a very instructive Paper on a difficult subject. There are, however, one or two points on which I have to disagree. Mr. Coupe gives "a typical analysis" of a charge suitable for enamelled work:—Si, 3.0 per cent.; Mn, 1.0 per cent. max.; S, 0.02 to 0.04 per cent.; phosphorus, 1.0 to 1.1 per cent., and then outlines the make-up for a charge for 2-ton cupola.

The manganese content seems very high indeed, and would, in my opinion, have a detrimental effect upon fluidity, bearing in mind the class of work, that is stove plate. The sulphur content would be ideal, but can this be obtained without special low sulphur coke?

With reference to the make-up for a charge for a 2-ton cupola, Mr. Coupe gives figures for coke which work out at 16 parts of metal to one of coke. Even given the most modern cupola, and excluding the bed charge, I fail to see how such metal can be of any use for light castings. Also the proportion of 6 cwt. light scrap and 1 cwt. 2 qrs. heavy scrap would demand a pig abnormally high in manganese and unsuitable for light casting work (allowing for loss in melt of 20 per cent.).

Yours, etc.,

"GRATES."

The British Cast Iron Research Association

ANNUAL MEETING AND LUNCHEON

The annual meeting of the British Cast Iron Research Association was held at the Hotel Victoria, Northumberland Avenue, London, W.C.2, last Thursday, and was followed by luncheon, at which the Association entertained many distinguished guests.

THE ANNUAL MEETING

MAJOR F. A. FREETH, O.B.E., D.Sc., F.R.S. (the retiring President) presided at the annual meeting. After the DIRECTOR (Mr. J. G. Pearce, M.Sc., F.Inst.P., M.I.E.E.) had read the notice convening the meeting and intimated the apologies received for non-attendance, and the minutes having been taken as read, the PRESIDENT presented the report and accounts for the year ended June 30, 1936. He said the occasion was the last on which he would have the honour of addressing the members as their President, having held that office for three years. He took the opportunity to say how much he had enjoyed his period of office, and to thank all concerned, especially Mr. J. G. Pearce, for the very kind way in which they had supported him.

Commenting on his official inspection of the Association's laboratories on July 23, 1936, the President said he had spent a very interesting day there; he wished to say again that he was very much impressed by the obvious efficiency with which the work of the Association was being carried out, and even more impressed by the manner in which the money available was spent with a view to securing maximum value. The Association had really made £1 do as much work as was done for 30s. in many other places.

With regard to cast crankshafts, another matter referred to in the report, the President admitted that when he had first heard of them he had not quite liked the idea; but he had found that his own car had a cast iron crankshaft, and, bearing in mind that he drove the car very hard, the crankshaft made of cast iron must be satisfactory. In a reference to the high temperature tests referred to in the report, the President emphasised the great importance of the elimination of creep. There were gas engineers, he said, who were very worried because of the manner in which cast iron used to creep at one time, but nowadays it does not creep to the same extent.

Discussing accommodation, the President drew particular attention to the facts recorded in the report, that the Association had acquired its first laboratory in 1924, that improvements were effected in 1926 and subsequently, and that the total area available at headquarters at the present time was 9,000 sq. ft. The Council wished to set up a building fund, and he had suggested to the Earl of Dudley, the President-Elect, that the Association might now try to provide a sinking fund. In the past, when things were good, British industry had not worried; when things were bad, we had wanted to worry, but had not anything with which to worry. He emphasised, therefore, that the Association should, under present conditions, try to save a little money.

Election of President

On the motion of MAJOR FREETH (who retired from the presidency under Article 23), seconded by MR. H. B. WEEKS (chairman of Council), the meeting unanimously elected the Rt. Hon. the Earl of Dudley, M.C., as President of the Association.

MR. H. B. WEEKS (chairman of the Council) proposed that the warmest thanks of the Association and Council be tendered to Major Freeth for his services as President, and that he be elected an honorary member. Mr. Weeks commented that, whereas, generally speaking, a President was re-elected for a second year and at the end of that second year he went into retirement, if not obscurity, Major Freeth had been asked to continue to serve as President for a third year, and had been pleased to do so. The members of the Association hoped that, although they could not ask him to continue in office longer, he would not go into retirement or obscurity, and for that reason had offered him the only honour they could confer—that of honorary membership of the Association. No further words were necessary to commend the resolution to the meeting.

MR. J. E. HURST seconded and the vote of thanks was carried with acclamation. Major Freeth was unanimously elected an honorary member.

MAJOR FREETH returned his thanks, and assured the members that he would continue to do all he possibly could, officially or unofficially; he was grateful to them for having given him the opportunity.

THE EARL OF DUDLEY
(President of the British Cast Iron Research Association).

Vice-Presidents

Mr. A. McKinstry, M.Sc., M.I.E.E., M.I.MechE., was re-elected a Vice-President of the Association, and Lord Austin of Longbridge and Professor Emeritus T. Turner were elected additional Vice-Presidents.

PROFESSOR T. TURNER, returning thanks for his election, said he had been associated with cast iron for so long that he had been named "Cast Iron Turner"; he had also been given other names which were not so pleasant. However, he would be glad to do anything he could in the future, as he had done in the past, for the founders and for the men in the foundry trade.

Vote of Thanks to Retiring Vice-Presidents

MR. T. MAKEMSON (General Secretary, Institute of British Foundrymen) proposed that the warmest thanks of the Association and Council be tendered to Mr. John Cameron, J.P., and Mr. H. James Yates who retired from office as Vice-Presidents under Article 23. It was always a pleasure, said Mr. Makemson, to tender sincere thanks for services rendered. In electing those gentlemen as Vice-Presidents the Association had felt that it was honouring them in one of the few ways in which it could honour prominent industrialists, and it recognised also that they were honouring the Association by their acceptance of office. They had not regarded their office merely as an honour, however, or as a sinecure, but had rendered valuable service to the Association by their encouragement and in other very practical ways.

MR. F. J. COOK seconded the resolution, which was carried with acclamation.

Re-election of Council

On the motion of MR. R. C. TUCKER, seconded by MR. P. A. ABERNETHY, the following Members of Council, who retired automatically under Article 27, were unanimously re-elected:—J. Arnott, A.I.C., A. J. Burn, W. T. Griffiths, M.Sc., T. M. Herbert, M.A., A. Hodgkinson, Major C. Howl, W. B. Lake, J.P., W. B. Parker, F.I.C., R. O. Patterson, S. H. Russell, H. H. Shepherd, G. A. Ure, J.P., H. B. Weeks, F.I.C.

The meeting closed by according votes of thanks to the Chairman and to the Director and staff.

THE LUNCHEON

THE RT. HON. the EARL OF DUDLEY, M.C. (the Association's newly-elected President), presided over a distinguished gathering at luncheon, having been formally introduced by his predecessor, Major F. A. Freeth.

Following the loyal toast, the PRESIDENT addressed the gathering, and said he felt more honoured and more flattered than he could say in having been invited to become President of the Association for the coming year, but at the same time he was very sensible indeed of his limitations. Nevertheless, he would do everything possible to further the prosperity of the Association.

The History of Dud Dudley

The President confessed that he did not know why he had been elected to his office, for his technical qualifications were extremely small. He was proud, however, to be a descendant of Dud Dudley, who had been concerned with iron production more than 300 years ago, and who, as the virtual founder of modern blast furnace practice, was therefore very largely the founder of modern foundry practice. The President hoped that the fact that he was a descendant of Dud Dudley partially justified his boldness and impertinence in having accepted his important office.

Dud Dudley had obtained his patent from James I as the result of rather smart practice! When still an undergraduate at Balliol he had foreseen the great possibilities of making iron with the aid of coal instead of smelting it by means of charcoal; and inasmuch as he and his relatives had owned large coal deposits, he had foreseen that that fact could not but actuate in his favour. Therefore, he had written to James I and had pointed out the importance, and indeed the necessity, of being granted his patent, owing to the fact that the cutting down of so many trees to make charcoal presented a great menace to the shipbuilding industries. That was a rather interesting fact. He was granted the patent; and the President was proud to think that Dud Dudley's invention had founded the industry which had since been developed to so remarkable an extent.

Blow-holes

Recalling his own small experience of foundry practice, the President said that when he had first entered business, his family had owned a small foundry in the Midlands, and had made, among other things, engine castings for Lord Austin. One of the President's duties, when a very young man, was to investigate complaints, and he could remember very well the many sleepless nights he had had, when blow-holes were dancing before his eyes; he could never quite make out whether or not it was Lord Austin's last letter of complaint which had caused those visions of blow-holes. At any rate, when the

foundry had been sold to someone else, those nightmares had mysteriously ended! As a steelmaker, and as a maker of cold blast iron, he was proud of his close association with the ironfounding industry.

Need for Research

Steelmakers were very large users of foundry products, and he could say with absolute safety and with the strong support of his close friend, Sir William Larke (Director, British Iron and Steel Federation), that the steelmakers, when buying plant, which embodied a large amount of cast iron, would always prefer to buy British. They must have, however, the latest and the very best plant, because they had to compete with steelmakers in other countries who were splendidly equipped, and if the British makers could not supply them, they must go abroad for it; there was no alternative. He submitted that the plant makers could not produce the very best plant, of the most up-to-date design, which was so essential, unless they supported to the fullest possible extent the scientific and research departments which would give them the ability to produce it. For that reason every foundry in the length and breadth of the land ought to support the British Cast Iron Research Association to the fullest possible extent. He was following a long line of distinguished Presidents, and his immediate predecessor was the extremely able Major Freeth, who represented a very large consuming industry. Major Freeth and the great industry which he represented (the chemical industry) had always been foremost in supporting scientific development and research in the widest possible form. One could be quite certain that the lessons which Major Freeth had preached during his tenure of office as President had borne fruit and would continue to bear fruit. Lord Dudley's foremost hope was that he also would be able to carry on that good work, that during his period of office the membership of the Association would increase, and that its work would prosper and extend.

Catering for Future Research

Since the war, and, indeed, before the war, we had experienced a very thin time, generally speaking, from the research point of view; money had not been available for research during recent post-war years; we had not had the opportunities of developing science as it should be developed, for there had been no confidence and not a great volume of trade. Other countries had had better opportunities, and it might be said by many that they were in advance of us at the present time in that respect. We were standing on a better wicket than they were at the moment, however, and it was up to us to make up the lost ground and to put ourselves once again into the pre-eminent position as regards invention, research and scientific discovery that we had held formerly. For that reason he felt perfectly certain that it would be wise for the ironfounders, as it was wise for the steel industry, to take advantage of the present good times—nobody knew how long they would last—not only to push ahead with research and scientific development as hard as they could, but also to make provision for future bad times, so that never again should we suffer as we had suffered during the awful years of depression since the war, when we had had to see ourselves superseded in the race of the laboratory. He hoped that everyone present realised the importance of collective action in that respect. In olden days we had benefited by wonderful individual discoveries; generally speaking, all the great scientific discoveries in olden times had come from British individuals, who had given the world the benefit of their inventive genius. Nowadays, however, it was only by collective action, by pooling resources, that we could once again take our place in the competition of the world. After all, it was being done by collective action in other countries, and it was of no use any country thinking that by individualism it could succeed against collective action in other countries; it could not be done. It was only by collective action, organised by associations such as the B.C.I.R.A., that we could ensure the future prosperity of our industry.

Better Premises Needed

Commenting upon the reference to accommodation, in the annual report of the Association for the year ended June 30, 1936, the President emphasised that no great Association could operate effectively and efficiently without proper accommodation, particularly an Association such as the B.C.I.R.A., which must have the most up-to-date laboratories, and equipment. Therefore, he hoped it would be possible during the good times that lay ahead to ensure the prosperity of the industry by giving the Association permanent, thoroughly modern and well equipped accommodation for its staff. He also drew attention to the first annual report of the British

Lord Austin of Longbridge
(Vice-President of the British Cast Iron Research Association).

Foundry School and pleaded for the fullest support of that school by all branches of the Association; he hoped that the school would have an increasing number of pupils and increasing support as time progressed. He understood that pupils were coming from the Dominions, and he would make it his business to assist that particular branch of work in every possible way.

Lord Austin

In a tribute to Lord Austin, who was elected that day a Vice-President of the Association, the President said that, so long as Lord Austin was a Vice-President, the future of the Association was assured. There were few people who knew more about foundry work than he or who realised more fully the importance of up-to-date foundry practice, and the Association was delighted to elect him a Vice-President, as well as to congratulate him upon his recent honour, which was so very well deserved.

Another whom the President welcomed was Sir William Larke, whose support he had enjoyed in other branches of his activities. The President also expressed the hope that a result of his own election would be to cement still more closely the association which had always existed, and should always exist, between the B.C.I.R.A. and the steelmaking interests.

Finally, the President again thanked the members of the Association for their welcome and for their kindness, and pledged himself to work for the fulfilment of the highest aspirations of the Association and the greatest possible prosperity of the industries it represented.

Sir Alexander Gibb, G.B.E., C.B., F.R.S., M.Inst.C.E., M.I.Mech.E., M.I.Chem.E., M.Am.Soc.C.E., M.E.I.C. (President, Institution of Civil Engineers), proposed a toast to the President, and said it was very right and proper that the Earl of Dudley should be President, bearing in mind that it was his ancestor, Dud Dudley, who had started to make grey iron and its derivatives by means of the heat from coal instead of from charcoal. Dud Dudley was born in 1599, and had started his system, which had been of extraordinary value to the world, in 1619. A fact which was of great importance to England was that before that time, *i.e.*, in the Middle Ages, there were 69 large forest areas in England alone; to-day, however, there are only four, those four being Windsor forest, the Forest of Dean, Sherwood Forest and the New Forest. But for the work of Dud Dudley we should not have had even those! One felt sure that the Society for the Preservation of Rural England would be very pleased with the results of Dud Dudley's efforts. He was one of the great benefactors not only of the industry, but of the human race, and the Association should be very proud to have his descendant as its President.

Corrosion Research

The Association, continued Sir Alexander, had done some extraordinarily good work in the way of research, and it was only by research that cheaper and more efficient methods of producing commodities could be attained. Over a period of nearly a thousand years there had been no progress at all in pure science or research. Following that period we had the work of Sir Isaac Newton, Galileo and some of the founders of the Royal Society, who had discovered the fundamental principles of science. The establishment of those principles was followed by engineering about the middle of the 18th century, and people such as those who represented the B.C.I.R.A. had turned the inventions and discoveries of the pure scientists to practical use, giving new employment to the inhabitants of Great Britain, who until then had been purely agricultural. Since then the engineering or the purely practical inhabitants of Great Britain had been using research more and more, but in the last few years research had come to be recognised as one of the most important things for the good of the country. The Institution of Civil Engineers was not very wealthy, but during the last year it had set aside a sum for research, to encourage in every way those who were doing research; he was sorry to say that the money had had to be taken from reserves. For the last 20 years the Institution's Sea Action Committee had been studying the effect of sea water upon different materials; the B.C.I.R.A. had been extraordinarily helpful in connection with that work, and he hoped it would continue to help, or that the Institution would continue to help the B.C.I.R.A.; the Institution would be delighted to do anything it could to help.

Flexible Cast Iron

Sir William Larke (Director, British Iron and Steel Federation), who supported the toast, said that, in his judgment, the Association could not have chosen a more able or more suitable President to further its interests and the interests of the industry it served.

It was very pleasing for Sir William to be able to remind the members of the Association that they were closely associated with the Iron and Steel Industrial Research Council, of which Mr. Pearce, the Association's able Director, was a member. As the result of the work of the members of the Association, even the proverbs of our language had been changed. It had been a custom to talk of things as being "cast iron," in the sense that they were totally inflexible and immovable. Mr. J. G. Pearce had, however, reminded us, in a recent Paper, that cast irons were being produced which the steelmakers were

(Concluded on page 372.)

Soundness in Iron Castings

LONDON AND BIRMINGHAM FOUNDRYMEN IN JOINT DISCUSSION

On October 24, a joint technical session of the London and Birmingham Branches of the Institute of British Foundrymen was held at the Charing Cross Hotel, London. Mr. V. Delport (President of the London Branch) presided during the earlier part of the meeting, and later invited Mr. G. W. Brown (President of the Birmingham Branch) to preside. Mr. H. Winterton (President of the Institute) was also present.

Mr. Delport, in extending a welcome to Mr. Brown and his fellow members of the Birmingham Branch, and to Mr. Winterton, said it was always an honour to welcome the President of the Institute to Branch meetings.

A Paper was then presented, on "Some Factors Influencing the Production of Sound Castings," by E. W. Wynn and D. Hope, which appears elsewhere in this issue.

Manganese and Chill

Mr. F. J. Cook (Past-President of the Institute) agreed with the authors that the problem of the use of manganese had not received due consideration. He related an experience of almost 40 years ago in connection with the making of cylinders for high-speed engines for generating electricity; these engines had to work at high steam pressures and with highly-superheated steam, and it was desirable to use chills in the bores of the cylinders. In those days the chemical analyses of irons were not understood as they are to-day, but after experimenting he had discovered that manganese was the ruling factor in respect of the chill. Subsequently he had arrived at a formula—which had been printed many times in the Institute's Proceedings—that if the percentage of manganese were more than three times the percentage of sulphur, it would produce a chill. The mixture he was using had a high sulphur content (0.12 per cent.) and he ruled that the manganese content must not exceed 0.4 per cent. With this practice no chilling effects were noticed, the castings were dense, and during machining one could not tell which part of the casting had been chilled. Dr. A. L. Norbury had continued that work and had put forward a more scientific formula, which was mentioned in the Paper. Mr. Cook added that not only had he avoided chill in the castings referred to, but he had produced a very much better and closer structure of iron than would have been produced if he had not adopted his formula. The iron had better wearing properties and was much sounder under pressure. In those days hydraulic test pressures of 600 lbs. per sq. in. were applied.

With regard to the effects of manganese on machine-tool castings, Mr. Cook emphasised that if the manganese content were increased, a "gritty" surface resulted. Unaided visual examination indicated a very open grain, but examination by means of a low-powered magnifying glass showed that the crystals became torn out by machining. It was not really an open grain such as was due to graphite.

Sometimes a glazed inclusion appeared in the iron; this was formed by silicon and manganese. He had drawn attention to it in a Paper which was presented to the American Foundrymen's Association. If the manganese content were within 0.4 of the amount of silicon—he had studied it over a range from 0.7 to 3 per cent. silicon—a glazed inclusion was always produced. He believed he had detected it in one of the high-manganese structures which the authors had shown at the meeting, though he could not be sure unless he examined the material at high magnifications and by throwing the pearlite out of focus.

Manganese Limits

Dr. A. B. Everest (Vice-President of the London Branch) suggested that some points advanced in the Paper seemed to be a little contradictory. It could be agreed that manganese, in the higher proportions, increased grain size, and he believed that in special castings, such as certain crusher rollers, high-manganese contents were used to give a very coarse grain and open surface which would bite on to the softer materials to be crushed. On the other hand, in the manufacture of high-duty irons, manganese was generally regarded as a beneficial element, giving clean castings and a good surface. In those cases the manganese content was generally from 0.6 to 1 per cent. He asked for the authors' opinion as to the useful limits for manganese in a high-duty iron. In some cases referred to in the Paper the manganese content was 1.5 per cent., which, possibly, was excessively high, but it would be useful to have their opinion as to whether it was safe to use 1 per cent. of manganese in an ordinary engineering iron.

Dr. Everest confirmed that manganese did refine the pearlite. It acted in the same way as nickel, in rendering an iron more heat-treatable. With 2 or 3 per cent. of manganese, the pearlite passed through sorbite to martensite, although he understood that in any iron which ordinarily showed a given depth of chill, manganese in excess of the amount necessary to balance the sulphur caused increased chill. The authors had given examples where the chill had been eliminated by high proportions of manganese, but Mr. Cook had said that he had obtained increase of chill with manganese and had found it necessary to restrict manganese. It would be interesting to have further light on that contradiction, and Dr. Everest looked forward to hearing the result of the authors' further work. On the Continent there were being made some special castings having manganese contents up to 15 per cent.; so that apparently there was a vast field to be explored in connection with the use of manganese in cast iron generally.

Dr. Everest also confirmed that in many cases an open structure and even the so-called pin-hole structure on the machined faces of castings were not necessarily pin-holes at all. He had seen several cases in which apparently open structures were due to the machine tool pulling out pieces of metal owing to the net-work structure of graphite in the surface .

Influence of Phosphorus

Mr. Shepherd said that although the authors' references to irons of low-phosphorus content were not intended to be derogatory to phosphorus in iron, Mr. Shepherd felt that the alleged ill-effects of phosphorus in causing porosity or unsoundness in castings had been very much over-estimated. He recalled one case where the experts had required castings to be made of low-phosphorus iron, and he was told that it was impossible to make the castings sound if the phosphorus content of the iron were more than 0.4-0.5. In fact, however, it was only by raising the phosphorus content to 1 per cent. that sound castings were produced at all. Phosphoric irons in this country were relatively cheap and were of great importance because of the abundance of phosphoric ores here. Previously the effects of poor foundry technique had been attributed too often to the highly-phosphoric irons, with the result that founders had resorted to alloy irons in order to overcome unsoundness, whereas possibly equal success could have been attained by the application of better foundry technique and more knowledge of the use of phosphorus.

Mr. F. J. Cook said that if the manganese content were increased beyond a certain point the structure of the iron altered and the castings produced were less sound than with lower manganese content, but if the manganese content were increased beyond a still higher figure, sound castings could again be produced. In hydraulic castings, such as big and thick cylinders, quite a number of people had increased the manganese content, with very bad results. It was necessary either to keep the manganese content very low or to use what were generally regarded as excessive percentages, in order to produce sound castings.

With regard to phosphorus content, he had satisfied himself by the formula he had suggested that if the silicon and carbon contents were maintained in the correct ratio, one could ignore phosphorus, or even use it to advantage.

Temperature Control

Mr. W. J. Molineux asked whether the authors, in making their series of test bars in irons of increasing manganese content, had controlled the temperature of the metal throughout. He mentioned the matter because, when making Perlit iron some years ago, he had cast some bars of varying diameter, from ¾ in. to 3 in., in order to ascertain where whiteness or the mottled appearance started, and in order to ensure strict comparisons he had found it necessary to control the temperature of the metal within fairly narrow limits, and to make the moulds in dry sand as the conductivity of the sand had a most important bearing. The cooling of the metal was controlled just as the pouring temperature was controlled. Perhaps this explained the apparent contradiction, referred to by Dr. Everest, in test bars of increasing manganese content, as shown in the table by Mr. Wynn. He asked for the authors' opinions concerning the method of adding the manganese to the iron in the Stein & Atkinson furnace; was firing resumed after each successive addition of manganese?

Authors' Reply

Mr. Wynn, replying to the discussion, said he was glad to note some measure of agreement in the opinions expressed by the speakers on the effects of manganese. His experience confirmed that of Mr. Cook with regard to the surfaces of castings having a pitted appearance due to the manganese-silicon compound. Where castings had been rejected due to openness on the surfaces, chemical and microscopic examinations always showed an increase in graphite size. No doubt there were occasions on which the troubles outlined by Mr. Cook did occur, but probably the practice followed at the authors' works prevented those troubles.

In reply to Dr. Everest's remarks, Mr. Wynn said it had been emphasised in the Paper that where possible the authors used irons as near as possible to the eutectic composition, and perhaps Dr. Everest had in mind the casting of alloys further removed from the eutectic composition. By that he meant that if one were using, on the one hand, an iron with a phosphorus content of 1 per cent., and, on the other hand, an iron in which the phosphorus content was reduced to 0.25 per cent., all the other elements remaining as before, it was necessary to increase the carbon content in the second case in order to bring the alloy up to the eutectic composition. Reducing the phosphorus content in an iron, without increasing the carbon content, a greater latitude of the manganese content was permissible; the further the iron receded from the eutectic composition the lesser was the effect of the other elements. In irons having a carbon content of 3 per cent., one could use a manganese content up to about 0.7 per cent. without causing serious difficulty in respect of graphite size; it was only when the carbon content was low that one could increase the manganese content to 1 per cent.

The effect of manganese in the low-phosphorus irons was to increase fluidity. In irons of 3 or 2.8 per cent. carbon, advantage was taken of the increased fluidity which manganese would give, and in an iron containing about 2.8 per cent. carbon and 7 per cent. manganese there was no apparent increase of graphite size. The lower the carbon content in the iron, the more difficult it became to make a sound casting with that iron, and, unless the manganese content were about 0.7 or 1 per cent., there was serious risk of the formation of blowholes in irons of low carbon content. To reduce the risk of unsoundness to the minimum he believed the highest total carbon irons were most suitable, but in many cases low-carbon irons had to be used for other reasons.

He agreed with Dr. Everest that with high manganese content there was an increased possibility of producing chilled edges to the castings; if denseners were used on the face of the mould, a chill was produced. The depth of chill was generally less with increased manganese content, and there was a line of demarkation where the effect of the chill ended. The tendency of manganese to sorbitise the pearlite indicates that it does tend to chill on thin edges, whereas, with low-manganese content, the chill effect tended to decrease to evenness of structure as the distance increased from the face to the centre. With high manganese content the chill was generally harder on the face.

Replying to Mr. Shepherd, he said the authors had not suggested that the low-phosphorus irons were useless, but had mentioned them in connection with the making of castings of complicated shape where solid contraction might cause trouble. He remembered that, when dealing with irons containing about 1 per cent. phosphorus, having great difficulty in getting the core irons out while the casting was red hot in order to prevent the castings cracking. Moreover, the use of such irons increased cost of production. With the lower-phosphorus irons there was less tendency to cracking, as they were stronger at elevated temperatures. Phosphorus certainly had its uses, and he agreed with Mr. Shepherd that its ill-effects were perhaps overemphasised in some cases, but he believed there was less risk of producing porous castings if the phosphorus content were limited, at any rate to below 0.7 per cent. Phosphorus had been referred to in the Paper as the high-phosphoric irons were weaker at elevated temperatures, and, therefore, the castings required to be more free, to allow of contraction, than was the case with the medium-phosphoric irons.

Dealing with Mr. Molyneux's question as to whether the pouring temperature of the metal was controlled, he said that the metal was preheated in the Stein & Atkinson furnace for half an hour, and the additions were made by means of briquettes. The briquettes were used not only because they reduced oxidation, but also because an alloy could be added more conveniently in that way. Instead of removing the elbow from the end of the furnace, one need only take out the burner and push the briquette through the burner end, which was quite a simple operation and one which did not involve much labour. There could not possibly have been much variation in casting temperature. Optical pyrometers were used, but he regarded them as relatively unreliable, and they were not mentioned in the Paper, because it was feared that a good deal of the discussion might have been directed to the question of the reliability of pyrometers. The best guide to temperature, in his opinion, was the actual condition of the experiment. The furnace was pre-heated for half an hour, during which period the temperature was raised to 1,500 deg. C.; metal was then added and heated for half an hour before adding manganese; after each manganese addition the furnace was operated for four minutes and tapped. As to the effects of possible differences in moisture content, in the sand, Mr. Wynn said that all the bars were cast in dry sand in order to avoid any possibility of variation in graphite size arising from the passage of gases through the metal.

Vote of Thanks

DR. EVEREST, when proposing a vote of thanks to the authors for their Paper, took the opportunity particularly to compliment Mr. Hope upon his excellent photo-micrographs.

MR. BOOTH seconded the vote of thanks, and said the Paper was most instructive, and was the type of which the Institute required more.

MR. WYNN, responding, paid a tribute to Mr. Hope, and said that if their future Papers were received as favourably as this one had been, the presentation of them would be a really pleasurable duty.

The British Cast Iron Research Association

(*Concluded from page* 370.)

apt to consider as steels. Speaking as an engineer—and even though his steel friends might reproach him afterwards—Sir William agreed with Mr. Pearce.

The task of seconding the expression of thanks to Lord Dudley, and the toast to Lord Dudley and the prosperity of the Association, was one of supererogation. The best way in which the members of the Association could express their thanks to their President—and Sir William associated himself with them—was not only to ensure that the requested funds were forthcoming in greater abundance for the development of the Association's research work, but also to see that the industry as a whole supported it and applied the results to the benefit of the country at large. That was the whole object of collective research, to improve the technical efficiency of our industries and to enable us to maintain our technological leadership in the industries of the world—he did not agree with the President that we had lost that leadership.

(The toast was honoured with enthusiasm.)

The PRESIDENT, in a brief response, said that if there were a "cast iron" certainty, it was that he would do everything possible to help the Association during his year of office.

The following Members and Guests were either present or had accepted invitations:—Abernethy, P. A.; Lord Austin of Longbridge; Bailey, T.; Baldwin-Webb, Col. J., M.P.; Bampfylde, J. W.; Bell, James; Bolton, L. W.; Bolton, T. W.; Booth, C. C.; Bridges, K. W. (Foundry Trades Equipment and Supplies Association); Brown, Sir Harold (Director of Armament Production); Carbutt, E.; Carpenter, Sir Harold, M.A., Ph.D., A.R.S.M., F.R.S. (President, Iron and Steel Institute); Chapman, Dr. F.; Chubb, W. F.; Clayton, G. C.; Colbeck, E. W.; Cook, F. J., M.I.Mech.E.; Cowan, H., B.Sc.; Crawford, J.; Darby, R.S.; Dawson, J.; Desch, Dr. C. H., F.R.S.; Dobson, W. E.; Lord Dudley; Elliott, T. G.; Evans, E. C.; Evans, N. L.; Everest, A. B., Ph. D.; Faulkner, V. C. (Editor, FOUNDRY TRADE JOURNAL); Fellows, A. A.; Field, H.; Fielding, A. L.; Findlayson, T. C.; Firth, T.; France, G. E.; Freeth, Major F. A., O.B.E., D.Sc., F.R.S.; French, Col. W.; Gardom, J. W. (Vice-President, Institute of Vitreous Enamellers); Gibb, Sir Alexander (President, Institution of Civil Engineers); Goodwin, Engineer Vice-Admiral Sir George; Goodwin, J. T.; Gough, Dr. H.; Gray, Dr. L. T. M.; Green, George; Grice, C.; Griffiths, W. T., M.Sc.; Hartley, H. A.; Hartley, Dr. H.; Hatfield, Dr. W. H.; Hatswell, R. W. (Worshipful Master, Founders' Company); Headlam-Morley, K. (Secretary, Iron and Steel Institute); Hepworth, J., M.P. (Vice-President, Institute of British Foundrymen); Herbert, Engineer-Commander D. P., R.A.N.; Herbert, T. M., M.A.; Hetherington, A. L.; Hooper, Barrington, C.B.E. (managing director, FOUNDRY TRADE JOURNAL); Hosking, R. G. (Chairman, British Foundry School); Hoskison, T.; Hunt, Dr. L. B.; Hurst, J. E.; Jackson, G. C. M.; Joel, Dudley, M.P.; Johnson, H. H.; Jolley, W.; Jones, J. C.; Lake, W. B.; Langhorne, A. E. A.; Larke, Sir William J.; Leckie, J. A., M.P.; Lewis, F. W.; Lobley, A. G.; Lunt, G. T.; McKinstry, A., M.Sc., M.I.E.E., M.I.Mech.E.; McRae-Smith, A. E., M.A.; Mackenzie, A. D., O.B.E., B.Sc.; MacLellan, W. Turner; Macnaughtan, D. J.; Makemson, T. (Secretary, Institute of British Foundrymen); Maunsell, R. E. L.; Moore, H. H., D.Sc.; Morgan, E., M.Sc.; Neave, D. P. C.; Norbury, Dr. A. L.; O'Neill, Dr. H.; Parker, T. H. G., M.C.; Parkes, W. B.; Pearce, J. G., M.Sc., F.Inst.P., M.I.E.E. (Director, British Cast Iron Research Association); Pendred, L. St. L.; Ramsay, A., M.P.; Richman, A. J.; Robbins, Brian G.; Rowden, W. F.; Rowley, C.; Sandberg, C. P.; Scott, H.; Scott, W.; Shannon, H.; Shaw, J.; Shepherd, H. H.; Skerl, Dr. J. G. A.; Slade, Dr. R. E.; Smith, H. Teeling; Smith, S. J.; Stanier, J. F.; Stewart, L. D.; Swinden, Dr. T.; Skelly, J. M.; Taverner, I. D.; Taylor, G. B.; Templeton, R. B.; Thomas, D.; Tucker, R. C.; Turner, Professor Emer. T., M.Sc., A.R.S.M., F.I.C.; Watlington, V.; Wedmore, E. B., M.I.E.E., F.Inst.P.; Weeks, H. B., F.I.C.; (Chairman of Council, British Cast Iron Research Association); Wheeler, Professor R. V.; While, A. J.; Whitham, G. S., C.B.E.; Williams, C. G.; Williams, S. V.; Winterton, H. (President Institute of British Foundrymen); Wood, D. H.; Young, Alexander; Young, H. T. (President, Institution of Electrical Engineers); Zehnder, C.

Steel Moulding Materials

The Second Steel Castings Report (Special Report No. 15) published by the Iron and Steel Institute for the Autumn Meeting held recently in Düsseldorf, contains the following outline of research being undertaken by the Moulding Materials Sub-Committee. The programme adopted is as follows:—

(1) The methods of testing moulding sands for steel-foundry use. (2) A continuation of Boswell's examination of possible British alternatives to Belgian or French moulding-sands. (3) The relation of the "bond" in naturally-bonded and synthetically-bonded sands to "stripping," "burning on," etc., including the properties of reclaimed sand. (4) The effect of the washes and paints on stripping and the casting skin. Investigation of the behaviour of special washes, paints, etc. (5) Investigations of the behaviour of synthetic bonds with: (*a*) Clean high-silica sand, (*b*) weak clay-bonded sand, and (*c*) the influence of grain characteristics on bonding, etc.

(6) The effect of pressure on the sintering and softening of moulding sands and "compos." (7) Methods for the preparation and reclamation of moulding materials. (8) The investigation of the properties of core bonds. (9) The volume changes in moulding sands and "compos" from 0 deg. to 1,400 deg. C., including the effect of composition, grading, ramming density, etc. (10) The effect of the thermal conductivity of the mould on the casting. Experiments with moulding materials of: (*a*) High conductivity, (*b*) low conductivity.

The Sub-Committee are also co-operating with other Committees in regard to standard sands and standard castings for experimental work, and are preparing a bibliography on the general subject of moulding materials.

THE MILLOM & ASKAM HEMATITE IRON COMPANY, LIMITED, it is reported, is preparing a reconstruction scheme which will make provision for arrears of preference dividend.

Some Factors Influencing the Production of Sound Castings*

By E. W. WYNN and D. HOPE

In this Paper it has been decided to deal with *some* of the factors influencing the production of sound castings. To discuss *all*, or even *many* factors would require too much space. It is intended to mention superficially some factors to which many workers have already devoted much time. In the main the authors wish to deal in detail with the results of personal experiments undertaken to give some proof of their opinion on the effect of manganese on cast iron. This opinion has been formed by practical experience, which is that absolute control of the manganese content is essential, if any control of the graphite flake size in the cast product is to be effected.

It will be gathered that only metal having a manganese content in excess of that which is necessary to satisfy the so-called sulphur balance equation has been considered. This equation is:

$S \times 1.7 + 0.3$ = minimum percentage of Mn.

Other workers have done much on irons of low manganese content, particularly in relation to sulphur, and have also stressed the graphitising action of Mn in such metal. It is not intended to stress this effect of Mn, but to emphasise the effect of this element on the graphite size of grey iron.

It was noticed that castings having the same percentage of silicon and total carbon had large variations in graphite size when the only other variable was the Mn content. Increase of this element gave increasing unsoundness in heavy sections as judged by pressure testing. Modern machine-tool makers insist on receiving castings which, after machining, show no openness of grain, and appear perfectly smooth and unmarred by the pitted appearance associated with large graphite.

Fig. 1 shows a 14-in. Audco valve tested to 250 lbs. per sq. in. for use on services up to 150 lbs. per sq. in. It was found, after casting a considerable number of these valve bodies, that although the silicon, total carbon and phosphorus remained the same in each case, the tendency towards porosity at heavy sections, such as occur at the throat, and particularly at the junction of the ribs, increased with increasing Mn content. Even if the porosity were not sufficient to allow seepage of liquid through the metal, the appearance of the bore was very open after machining. This was due to the formation of large graphite flakes at the positions already mentioned. The sectional thickness of this casting varies from 1 to 3 in.

Sand

Sand plays a very important part in the production of castings, and is responsible for many wasters because of lack of permeability. Permeability can be increased by judicious venting, but few moulders seem able to use a vent wire properly, and therefore sand should, where possible, be graded and mixed to give the desired permeability without resort to this practice. Lack of permeability is the chief cause of scabbed castings, broken moulds, sand inclusions and like defects.

Lack of refractoriness is responsible for poor appearance and machining troubles, due to sand adhering or fusing to the surface of the metal. This increases machining difficulties and fettling costs rather than being a cause of unsoundness.

Control of moisture content is also essential in order to avoid blow-holes and loss of per-

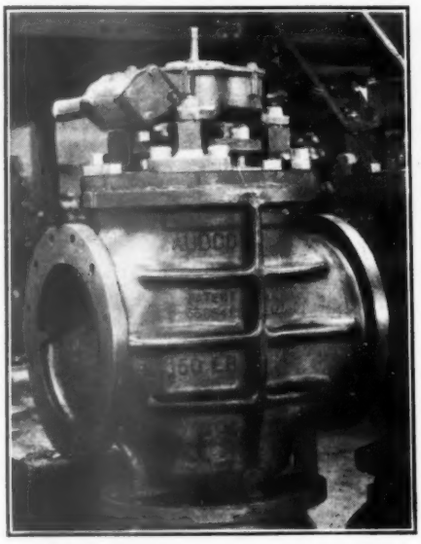


FIG. 1.—FOURTEEN IN. GUIDE VALVE.

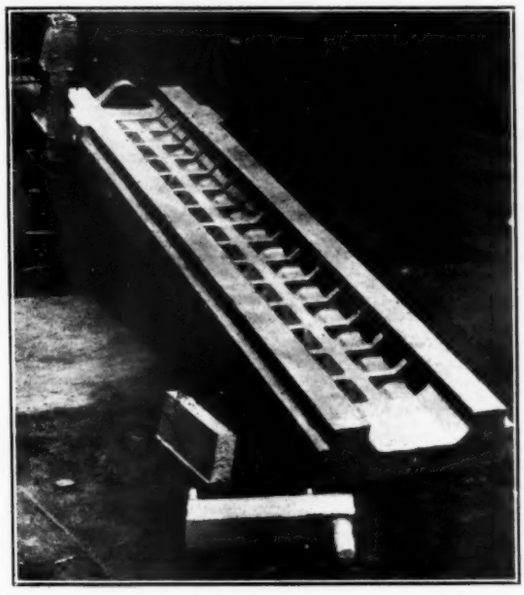


FIG. 2.—MACHINE TABLE.

FIG. 3.—SECTIONED FEEDER.

FIG. 4.—CASTING EXHIBITING A HOLE WITH EXTRUSIONS.

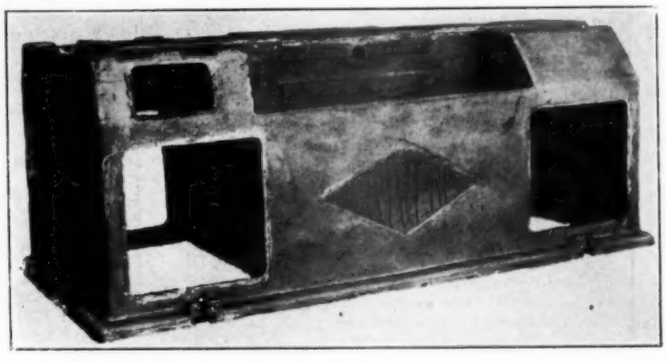


FIG. 5.—MACHINE BED.

* A Paper read before a joint meeting of the London and Birmingham Branches of the Institute of British Foundrymen, Mr. V. Delport presiding.

meability. It is also possible seriously to affect the structure of the casting as gases, generated by the contact of hot metal with the water in the sand, pass through the casting. Excess moisture is frequently the cause of chilled edges, etc. Control of moisture content is not nearly so important if the mould be dried before casting. The use of the Speedy moisture tester offers a very accurate and simple method of routine sand control. Care should be taken in ramming the mould, and is generally done more efficiently by machines.

Fig. 6.—Graphite. × 60.

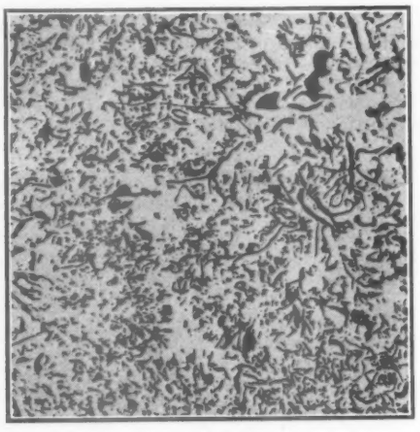


Fig. 7.—Graphite. × 60.

Runners

Runners are frequently contributory causes of unsoundness, and require skilled and careful judgment in their design and location. No exact formula has yet been devised which is applicable in all cases. It is frequently desirable to fill a mould from one point, but lack of crane capacity, or adequate ladles, etc., forces the foundryman to use two or more runners.

The functions of a runner are to form an entry for the molten metal to the mould and to prevent access of slag, sand, etc. The correct speed which is controlled by the area of down-gates and in-gates is determined by such factors as size of casting, thickness of section, composition and temperature of the metal, etc. This important part of the mould is very often left to the discretion of the moulder, but it has been found that a large number of faulty castings can be avoided, if runners are definitely fixed to the pattern and designed by a responsible official.

Various types of runners, such as spinners and strainers, have been designed with the intention of preventing access of sand, slag, etc. These are too commonly known to warrant much discussion in this Paper, but an interesting example of a runner which was the deciding factor in the successful founding of a very difficult casting is shown in Fig. 2. The weight of this machine table casting is approximately twenty-five cwts., its length is 8½ ft., the width is 2 ft., and the thickness is 10 in.

The section varies from 1 to 6 in. The casting was fed by the two feeders shown at the top, and although this might not appear to be the most advantageous position, it was the only possible location in this case. The runner can be seen at the front of the illustration, and slag inclusions can be seen on this portion of the runner at the left-hand side. This runner is a block of 5 in. by 3 in. by 30 in. long, and is connected to the casting by four in-gates at the base of the block; each in-gate has an area of approximately ¾ sq. in. Two down-runners were placed on top of the block, one inch from each end. The total area of these down-runners was 4 sq. in. Previous to the adoption of this type of runner most of these castings showed slag inclusions on the top face. The casting has to be machined on the top side and bottom faces, and slots 1½ in. deep cut in the bottom face. The casting will not pass inspection if the bottoms of the slots are more open than the face of the table.

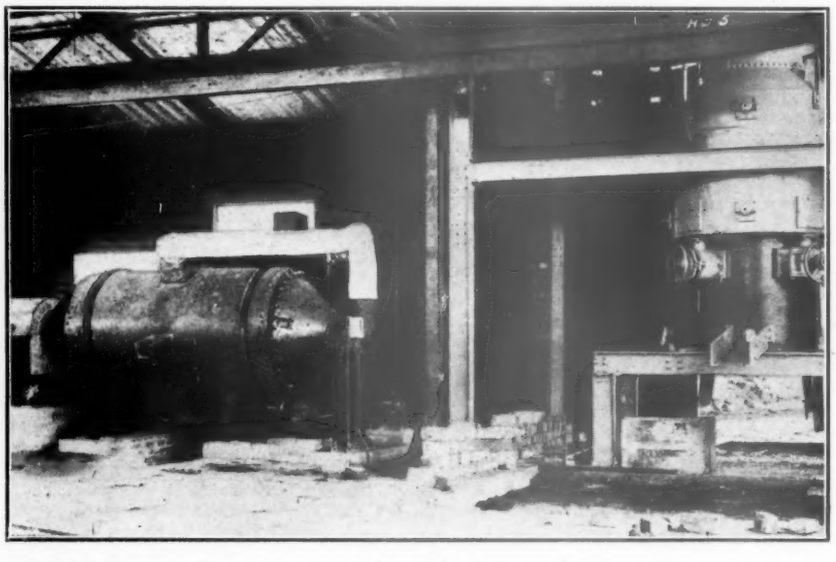


Fig. 8.—Balanced-Blast Cupola and Stein & Atkinson Oil-Fired Rotary Furnace.

Feeders

The correct design and positioning of feeders is of vital importance, if they are to function as a reservoir from which the casting will receive metal when contracting during solidification.

Table I.—*Physical Tests on Bars.*

No.	Dia. Ins.	Centres. Ins.	Deflection. Ins.	Trans. rup. stress. Tons per sq. in.	Calculated tensile. Tons per sq. in.
1	0·748	18	0·133	24·87	13·80
2	0·759	18	0·130	24·9	13·80
3	0·755	18	0·135	28·9	16·05
4	0·773	18	0·135	24·3	13·50
5	0·775	18	0·135	28·5	15·80
6	0·760	18	0·112	20·46	11·40
1	1·209	18	0·159	35·2	19·45
2	1·219	18	0·135	32·45	18·00
3	1·205	18	0·089	26·37	14·60
4	1·221	18	0·169	33·4	18·55
5	1·214	18	0·142	26·0	14·45
6	1·209	18	0·142	28·6	15·80
1	2·249	18	0·135	32·1	17·90
2	2·269	18	0·133	27·9	15·50
3	2·264	18	0·124	26·1	14·50
3	2·276	18	0·136	30·7	17·05
5	2·278	18	0·146	28·25	15·70
6	2·259	18	0·124	28·3	15·70

Lack of feeding is a frequent cause of open structure and cavities in the centre of heavy sections.

Fig. 3 illustrates a feeder which was properly designed and placed, and gives some idea of the size of the hole which would have occurred in the casting, unless adequate provision had been made for the reduction in volume.

Fig. 4 shows a casting which was not properly fed, resulting in the formation of a very large cavity. This defect was not discovered by the user of the casting. It looked perfectly sound, but was rejected for sand and slag inclusions under the surface, which were exposed on machining. Owing to the very nature of shrinkage cavities, the defect is usually only discovered after a considerable amount of work has been done on the casting, or after breakdown in service. It is sometimes only possible to feed a casting through a passage kept open by the movement of a steel rod, thus allowing molten metal to run into the casting from the reservoir above. This is a very undesirable method, and should only be resorted to when self feeders are not practicable.

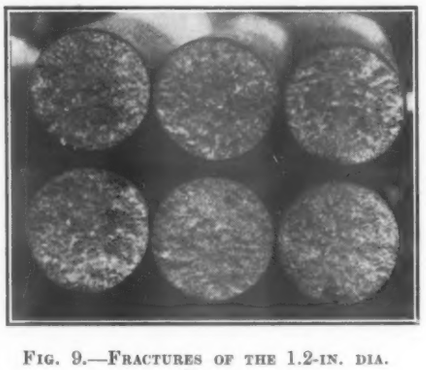


Fig. 9.—Fractures of the 1.2-in. dia. Bars.

Most moulders forget that it is impossible to push liquid iron down a 1-in. hole with a ½-in. rod. The result of their pushing is that the bottom surface of the mould or cores, immediately under the reservoir, is broken by contact with the feeding rod. Frequent additions of metal to the reservoir are necessary. Often metal

of different composition is used, which may result in open porous spots under the feeder. If rod feeding has to be resorted to, many wasters can be avoided by teaching the moulder that the movement of his rod is only to prevent the solidification of metal in the channel between the casting and the metal reservoir.

Solid Contraction

Provision must be made during the making of the mould and cores against the possibility of warped and cracked castings, caused by the contraction of the metal after solidification. If it be impossible so to construct the cores and mould to allow of this, the casting must be freed by removal of the cores, or mould, or both, as soon after pouring as possible. This practice, however, generally increases production costs. Modern core-sand practice and metallurgical developments have enabled foundrymen to make castings which are very liable to crack during cooling, with much less risk than was possible with the old loam sand cores and phosphoric irons. The fact that moulders are now able to dispense with heavy reinforcements of the cores, and that oil-bonded sands after heating readily disintegrate and flow from the casting face, has also helped to reduce the number of cracked castings.

The production of the casting shown in Fig. 5, using loam sand cores, would have been attended by great risk of cracks occurring at these points. None of these cores was removed until the casting was cold. The weight of the casting is 33 cwts., the length 8 ft., the depth 4 ft. and the width 4 ft., whilst the general thickness of section is $\frac{3}{4}$ in. It was cast the reverse way up to the position shown, and in spite of the heavy slide on the top face no feeding was necessary.

Composition of Metal

The composition of metal is, of course, a very important factor, but it is useless pouring good metal into a poor mould. It is personal experience that the production of castings in metal of suitable composition for modern engineering requirements demands much greater care and skill in making the mould than was required for the old phosphoric engineering irons. Phosphorus has been studied by many workers, and its influence on soundness is well known and understood by most foundrymen. Porosity and unsoundness due to segregation of iron phosphide eutectic will not be considered in this Paper. Total carbon is of vital importance and must be controlled as founding difficulties increase with reduced total carbon content. Many foundrymen use this type of metal because the influence of silicon and manganese on graphite size is less than when irons of high carbon content are used. The authors have found that other troubles encountered, such as high shrinkage, mould erosion, occluded gases, etc., very considerably increase production costs and risk of unsoundness. They are mainly concerned with the production of sound castings, so that anything which tends to increase unsoundness is avoided. It is thought that ferrous alloys as near the eutectic composition as possible are the least difficult to handle for the authors' personal requirements. The difficulties of obtaining eutectic alloys at will can be easily appreciated, but the difficulty of reaching an ideal is no reason why it should not be attempted.

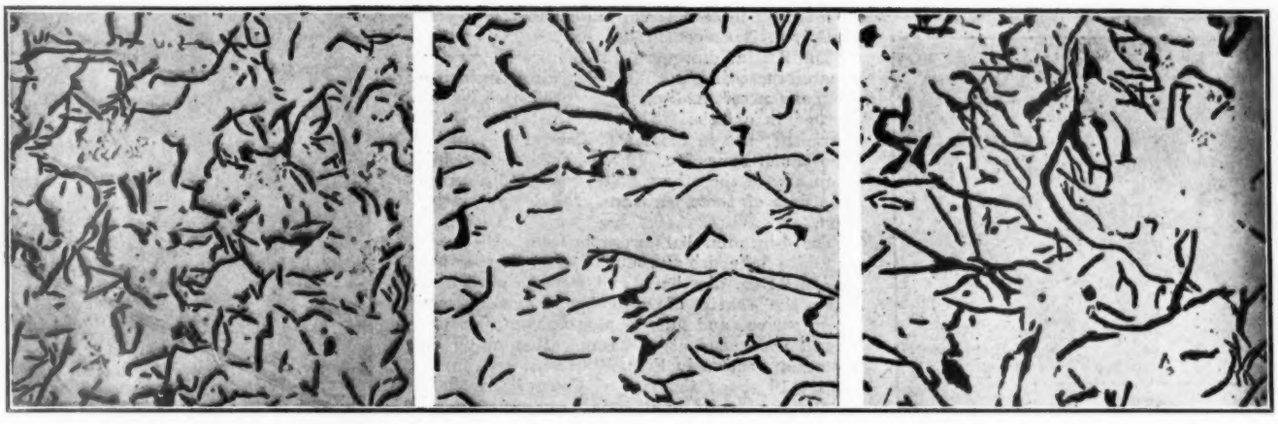
The extrusion in the cavity of the casting shown in Fig. 4 would be of almost eutectic composition, as that portion of the metal to solidify last would be squeezed into the cavity by the changing volume of the already-solid portion of the casting. The chemical analysis of the base metal was:—T.C, 3.45; Si, 1.25; Mn, 0.67; P, 0.043; S, 0.103, and Ni, 0.295 per cent., and of the extrusion: T.C, 3.85; Si, 1.18; Mn, 0.59; P, 0.060; S, 0.041, and Ni, 0.295 per cent. It is interesting to note the great difference in the sulphur and manganese content between the two metals.

Fig. 6 shows a photomicrograph of the base metal, revealing fairly large graphite flakes, whilst Fig. 7 illustrates the extrusion. The remarkable difference in the size and type of graphite is apparent; that shown in Fig. 7 is the type generally associated with strong, sound cast iron.

Silicon is a very important element and has strong influence on size and quantity of graphite; its control is relatively easy and well understood in the foundry. The effects of manganese, however, seem to be rather obscure, in spite of the fact that a large number of workers have studied this phase. The authors undertook an experiment to prove the effect of manganese on graphite flake size, soundness, and surface finish. Four charges composed of 4 cwts. of unannealed malleable iron scrap, and 2 cwts. of Workington hematite, were melted in a 26-in. balanced-blast cupola, tapped in two 12-cwt. batches into a 15-cwt. ladle, and transferred to a Stein & Atkinson oil-fired rotary furnace.

Fig. 8 shows the two melting units. It was a simple matter to pour the metal, which was carried along the mono-rail shown at the top, into the rotary furnace by way of the spout. A brick was placed at the front of the spout to prevent metal flowing out, the spout being slightly higher than the position as shown.

The furnace was then rotated for half an hour. Five additions of Mn were made at five minute



Figs. 10, 11 and 12.—Graphitic Structure of 4-in. Bars. × 60.

Figs. 13, 14 and 15.—Graphitic Structures of 4-in. Bars. × 60.

intervals. Manganese briquettes, being unobtainable, were made in the foundry, using sufficient 75 per cent. ferro-manganese to give 3 lbs. of Mn per briquette. The analysis of the ferro-manganese used was 6.88 per cent. T.C, 0.89 per cent. Si, and 75 per cent. Mn. The furnace was oscillated during the four minute intervals between each addition. After the four minute oscillation 2 cwts. of metal were tapped and cast into two moulds, one containing test bars of the following diameters:—0.75, 1.2, 2.2 and 4 in., and the other an ordinary Audco 4-in.

FIG. 16.—PEARLITIC STRUCTURE ETCHED PICRIC ACID. × 600.

valve body. The section of the latter varies from ¾ to 2 in. Each valve body was broken, and found to be grey, with the same tendency to increasing graphite size as was shown by the 2.2-in. test bars. After testing, the fractures of each set of bars were closely examined. The 0.75-in. diameter bars show little variation, and were mainly white iron. The fractures of the 1.2-in. bars, shown in Fig. 9, were very interesting, and were found to be increasingly grey with increasing Mn content.

All the bars except the 4-in. dia. ones were tested and gave the results shown in Table I. These are given mainly as a point of interest. Investigation of the influence of manganese on the strength of the irons was not intended. It will be noticed that strength has not increased with increasing manganese content; this may be due to the increased size of graphite.

It is difficult to show by means of a photograph the variation in structure, but from Fig. 9 it will be seen that there is a definite tendency to increasing greyness from bar No. 1 to bar No. 5. Bar No. 6 shows a slight reappearance of mottle, although the manganese content of bars No. 5 and 6 was practically the same, with a slight increase in silicon in bar No. 6.

Samples for chemical analysis were taken from the centre of each 4-in. dia. bar. The total carbon remained almost the same. There was, however, an appreciable decrease in the combined carbon from No. 1 to No. 4. Bar No. 5, which has the most open structure, showed the highest percentage of combined carbon. The 1.2-in. dia. bar in Series 6 showed reappearance of mottle, but silicon in that series had increased approximately 0.10 per cent.

The 2.2 in. dia. were all completely grey and showed increasing openness of grain with increase of manganese. A disc was sawn off each bar and turned in a lathe. The machinist did not find any difference in machineability of the metal. The bar of series No. 1 had a much better finish than any of the others. The machined discs and fractures of these bars are available for inspection.

The 4-in. dia. bars were broken. Increasing graphite flake size was much more apparent than in the 2.2-in. dia. bars, and sections were taken from the centre of each bar for microscopic examination, and microphotographs of these unetched specimens at a magnification of 60 diameters are shown in Figs. 10 to 15.

Fig. 10 shows the size of the graphite flakes in the base metal used for this experiment. It has the typical appearance of a good quality high strength cast iron which would machine easily and give good surface finish and soundness.

Fig. 11 shows the effect of the first increase in manganese. There is a perceptible increase in length and thickness of the graphite flakes. A flake is shown which extends almost across the section.

In Fig. 12 can be seen the definite increase in the flakes as a result of further addition of manganese, although the number of flakes does not seem to have increased.

Again, in Fig. 13, with further increase in manganese, the graphite flakes are larger. An iron of this type would take a very poor finish, and would be of little use in any corrosive service, as intergranular corrosion would be definitely accelerated.

Fig. 14 shows an increase in graphite size. The manganese increase in this case is about 0.35 per cent. Fig. 15 is very similar to Fig. 14, although ferro-silicon was purposely added to the melt before this bar was cast, in an attempt to prove that the effectiveness of silicon as a graphitiser was not affecting the results of this experiment. In order to prove that, although the size of the graphite flakes increased, the matrix remained entirely pearlitic, the two sections taken from the 4-in. bars Nos. 1 and 6 were etched with picric acid and magnified to 600 dias. The former, shown in Fig. 16, exhibits no free ferrite surrounding the graphite flakes, although pearlite is rather coarse, whilst the sample from No. 6 showed no free ferrite round the graphite, but some refining of the pearlite had taken place.

The control of graphite size in the casting shown in Fig. 17 is essential. Large graphite would cause weakness at the corners and reduce the wearing properties of the two slides. The casting is a body for a heading machine which is subject to great variation in load; its approximate weight is 2¼ tons, and the thickness of section up to 7 in. The casting was fed at each end; all the cores were made in oil sand and stripped easily.

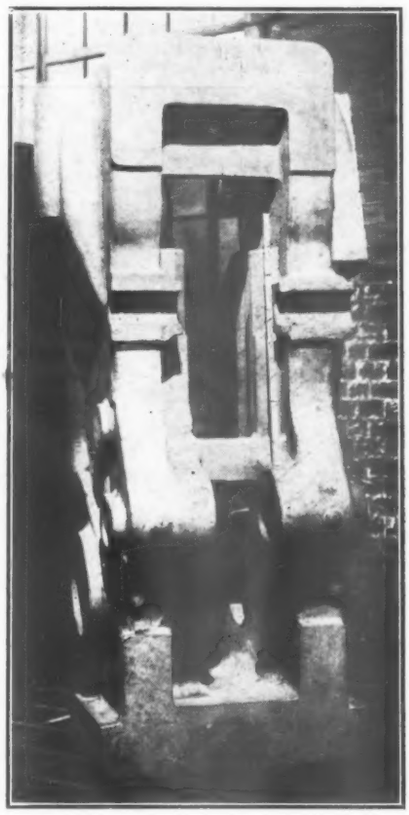


FIG. 17.—HEADER BODY CASTING WEIGHING 2¼ TONS.

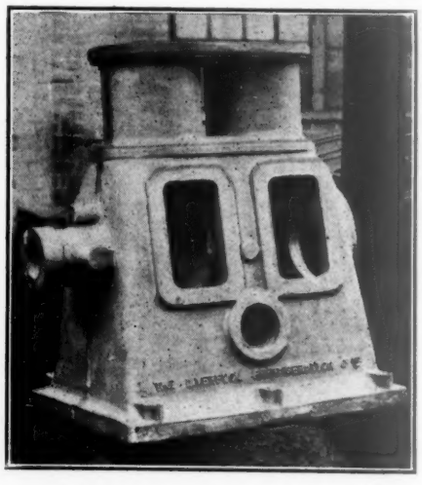


FIG. 18.—COMPRESSOR CASTING.

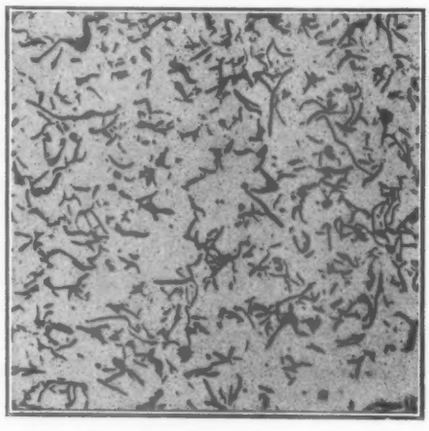


FIG. 19.—GRAPHITE. × 60.

FIG. 20.—GRAPHITE. × 60.

Fig. 18 shows an ammonia compressor body. The importance of pressure tightness and absence of large graphite in any casting which is to be

(*Concluded on page* 379.)

Second Report of the Steel Castings Research Committee

BY A JOINT COMMITTEE OF THE IRON AND STEEL INSTITUTE AND THE BRITISH IRON AND STEEL FEDERATION

(*Continued from page* 362.)

SECTION III.—The Fluidity of Iron-Carbon and Other Iron Alloys

By PROFESSOR J. H. ANDREW, D.Sc., R. T. PERCIVAL, B. MET., and G. T. C. BOTTOMLEY, B.MET. (Department of Metallurgy, University of Sheffield).

PART II

Tables I to VII give the fluidity values obtained for the various series.

TABLE I.—*Armco Iron Series.* (*Containing 0.02 per cent. Carbon.*)

No. of cast.	Casting temperature, deg. C.	Distance. In.
6	1,540	1
5	1,550	6
1	1,595	13
—	1,600	13½

TABLE II.—*Carbon Series.*

No. of cast.	Carbon, per cent.	Casting temperature, deg. C.	Distance. In.	Distance at 1,600 deg. C. In.
N 47	0.07	1,546	9½	—
48	0.07	1,520	1⅜	14½
45	0.17	1,555	10½	—
46	0.17	1,530	3	15
9	0.33	1,555	11	—
10	0.33	1,520	2½	16
43	0.45	1,600	17	—
44	0.45	1,540	11½	17
41	0.64	1,600	18	—
42	0.64	1,525	7	18
37	0.71	1,555	13½	—
38	0.71	1,515	8½	18
17	1.16	1,525	14	—
18	1.06	1,505	12	22
49	1.72	1,535	18½	—
50	1.72	1,470	11½	29½
87	2.2	1,480	20⅜	—
88	2.2	1,430	12	36
85	2.6	1,425	14½	—
86	2.6	1,360	4½	44
69	3.75	1,405	50	—
70	3.75	1,355	40	90

PART III

It has been assumed in the past that the position of the liquidus on the temperature axis for any particular alloy gives the point where that alloy possesses zero fluidity. On this assumption, curves have been plotted showing the relationship between fluidity and temperature for each composition. Examples of these are shown by broken lines in Figs. 9 to 12 for the iron-carbon alloys, containing 0.17, 0.71, 1.72 and 3.75 per cent. of carbon respectively. From these curves a value in inches for the fluidity of each alloy at 1,600 deg. C. was obtained. These values were then used for constructing the curves in Figs. 13 to 16, which indicate the relationship between fluidity and composition at 1,600 deg. C.

TABLE III.—*Silicon Series.*

No. of cast.	Silicon, per cent.	Carbon, per cent.	Casting temperature, deg. C.	Distance. In.	Distance at 1,600 deg. C. In.
A 1	3.04	0.48	1,570	15½	—
2	0.41	0.37	1,570	11½	17
3	14.9	0.40	1,600	Filled spiral	70
4	0.81	0.40	1,545	4½	18
5	10.5	0.38	1,600	49½	49½
6	1.32	0.39	1,540	4½	19
7	6.9	0.40	1,600	31½	31½
8	1.97	0.38	1,570	10½	20
9	3.95	0.41	1,580	16½	22½
10	19.7	0.40	1,510	Filled spiral	—
11	19.9	0.38	1,390	44½	84

TABLE IV.—*Phosphorus Series.*

No. of cast.	Phosphorus, per cent.	Casting temperature, deg. C.	Distance. In.	Distance at 1,600 deg. C. In.
91	2.75	1,485	10½	—
92	2.75	1,445	3	31½
93	0.0	1,485	Filled	—
94	9.0	1,350	50	92
95	13.0	1,460	Filled	—
96	13.0	1,350	52	96

for the following series of alloys:—(i) Iron-carbon; (ii) iron-silicon (containing 0.40 per cent. of carbon); (iii) iron-manganese (containing 0.50 per cent. of carbon); (iv) iron-phosphorus. In each case the temperature for zero fluidity, in the temperature/fluidity curves, was obtained from the equilibrium diagrams which are generally accepted. It seems evident that many of these diagrams are not applicable, as they only relate to carbonless alloys, and it is proposed to incorporate thermal data in subsequent investigations on this subject, particularly in the cases of the iron-manganese alloys and the more complex ternary systems which are not being discussed at present.

However, one may usefully consider the fluidity data from the iron-carbon alloys in conjunction with the equilibrium diagram. It will be noticed that changes in direction of the fluidity/composition curve (Fig. 13) correspond very closely with those in the liquidus of the diagram. As one would expect, the addition of carbon to iron increases the fluidity, provided the casting temperature is kept constant. This increase, however, is very slight over the peritectic range, that is, between 0.07 and 0.71 per cent. of carbon. With further increases of carbon beyond 0.71 per cent., there is a noticeable continuous increase in fluidity up to the eutectic composition (4.3 per cent. of carbon).

It may be emphasised at this point that the foregoing curves have indicated that the most fluid of the iron-carbon alloys is the eutectic alloy, a fact generally accepted and which did not need to be confirmed by these experiments.

However, a more interesting result is indicated in the peritectic range, where apparently a constant fluidity was obtained. In order to analyse this apparent discrepancy, another possible

TABLE V.—*Manganese Series.*

No. of cast.	Manganese, per cent.	Carbon, per cent.	Casting temperature, deg. C.	Distance. In.	Distance at 1,600 deg. C. In.
57	0.96	0.48	1,540	10	—
58	0.96	0.48	1,500	5	19½
75	2.2	0.50	1,520	11½	—
76	2.2	0.50	1,485	6½	22½
81	6.05	0.53	1,505	8½	—
82	6.05	0.53	1,490	3½	24
89	13.6	0.57	1,490	13¾	—
90	13.6	0.57	1,460	4	29
83	17.6	0.55	1,540	21½	—
84	17.6	0.55	1,485	12½	30
77	20.5	0.58	1,505	31½	—
78	20.5	0.58	1,455	17	46

TABLE VI.—"*Liquidus*" *Series.*

Composition. Per cent.	Temperature above Liquidus as origin. 10 deg. C. Distance. In.	30 deg. C. Distance. In.	50 deg. C. Distance. In.
Armco iron ..	5½	9½	12
0.07 carbon ..	3½	8	11
0.17 ,, ..	5	10½	13½
0.33 ,, ..	5	10½	13½
0.71 ,, ..	4.8	9.3	12
1.06 ,, ..	3.3	8	11.1
1.72 ,, ..	1.2	4	7.9
2.20 ,, ..	1.5	4.5	7.2
3.75 ,, ..	2	6.5	11
2.75 phosphorus	2	5	8.2
9 ,, ..	2	7	13
13 ,, ..	3	8	13
0.50 carbon ..	5	10	13
0.96 manganese ..	3.6	8.7	10
2.2 ,, ..	4.0	9	11
6.05 ,, ..	3.6	9	11
13.6 ,, ..	4.8	11.6	17.2
17.6 ,, ..	5.6	13.4	21
20.5 ,, ..	7.2	17	23.5

TABLE VII.—"*Solidus*" *Series.*

Composition. Per cent.	Temperature above Solidus as origin. 10 deg. C. Distance. In.	30 deg. C. Distance. In.	50 deg. C. Distance. In.
Armco iron	5½	9½	12
0.07 carbon ..	1½	4	7½
0.17 ,, ..	1½	4.8	8
0.33 ,, ..	1½	3.8	6
0.71 ,, ..	0.3	0.6	1.6
1.06 ,, ..	0.1	0.5	1.0
1.72 ,, ..	0.1	0.2	0.4
2.20 ,, ..	0.2	0.8	1.5
3.75 ,, ..	1.3	4.0	6.7
2.75 phosphorus	0.1	0.2	0.3
9.0 ,, ..	2	5	8
13.0 ,, ..	2	5	9
0.50 carbon ..	1.0	3.0	5½
0.96 manganese	1.3	4	6.6
2.2 ,, ..	1.5	4.2	7.2
6.05 ,, ..	2.0	4.4	7.6
13.6 ,, ..	2.4	5.0	9.0
17.6 ,, ..	2.4	6.4	10.4
20.5 ,, ..	3	9	15.5

assumption was made, namely, that the temperature of zero fluidity for any particular alloy does not occur at the liquidus on the equilibrium diagram, but at the solidus. In other words, flow may possibly continue after a portion of the

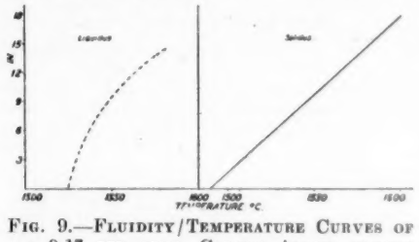


FIG. 9.—FLUIDITY/TEMPERATURE CURVES OF A 0.17 PER CENT. CARBON ALLOY, TAKING THE LIQUIDUS AND SOLIDUS RESPECTIVELY AS ZERO FLUIDITY.

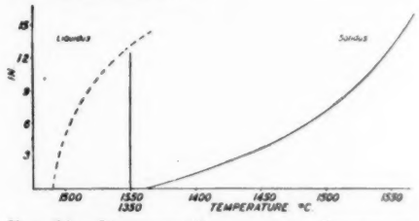


FIG. 10.—FLUIDITY/TEMPERATURE CURVES OF A 0.71 PER CENT. CARBON ALLOY, TAKING THE SOLIDUS AND LIQUIDUS RESPECTIVELY AS ZERO FLUIDITY.

alloy is solid. Moreover, by taking one casting temperature (1,600 deg. C.) the degree of superheat varied with each alloy. A second series of temperature/fluidity curves was therefore plotted, and this time the point of zero fluidity

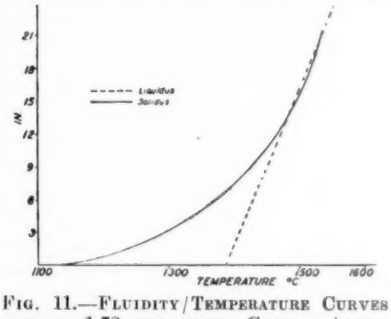


FIG. 11.—FLUIDITY/TEMPERATURE CURVES OF A 1.72 PER CENT. CARBON ALLOY, TAKING THE LIQUIDUS AND SOLIDUS RESPECTIVELY AS ZERO FLUIDITY.

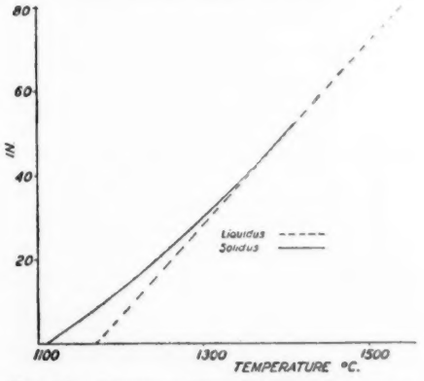


FIG. 12.—FLUIDITY/TEMPERATURE CURVES OF A 3.75 PER CENT. CARBON ALLOY, TAKING THE LIQUIDUS AND SOLIDUS AS ZERO FLUIDITY.

(the origin) was taken at the temperature of the solidus for each alloy. Examples are shown in Figs. 9 to 12 (continuous lines). In these and subsequent diagrams they are referred to as either "liquidus" or "solidus" curves, depending on their point of origin with regard to fluidity.

Fluidity values for each alloy were obtained from these curves at temperatures 10 deg. C., 30 deg. C. and 50 deg. C. respectively above the point taken as zero fluidity (that is, "solidus" or "liquidus"). From these figures, the fluidity/composition curves shown in Figs. 17, 18 and 19 were plotted. The relevant portion of the equilibrium diagram is included in each case.

Considering the iron-carbon alloys (Fig. 17), it will be observed that the general form of the liquidus and solidus curves are similar. The

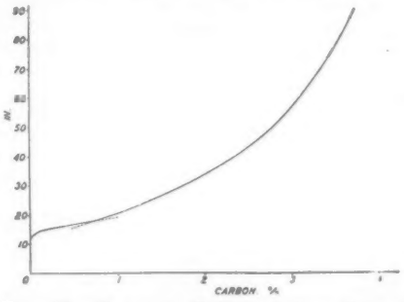


FIG. 13.—FLUIDITY CURVE OF IRON-CARBON ALLOYS AT 1,600 DEG. C.

liquidus curves show a decrease in fluidity from pure iron to 0.07 per cent. of carbon, then an increase to 0.17 per cent., then constant fluidity between 0.17 per cent. and 0.71 per cent. of carbon, followed by a decrease to a minimum at 1.8 per cent. of carbon, after which there is a steady increase up to 4.3 per cent. of carbon. In the solidus curves there is a marked decrease in fluidity from 0.17 per cent. of carbon to 0.71 per cent. of carbon.

Correlating these results with the equilibrium diagram, it would appear that by using the solidus as the point of origin more precise information is obtained, and that where the liquidus-solidus range is a maximum, the fluidity is a minimum. Thus, as the carbon content increases from zero to 0.07 per cent., the liquidus-solidus range increases and the fluidity decreases. With further increase of carbon up to 0.17 per cent. the range decreases to a minimum and the fluidity curve shows its first maximum. Again, as the carbon is further increased the range increases, with a corresponding decrease in fluidity. This decrease in fluidity continues until

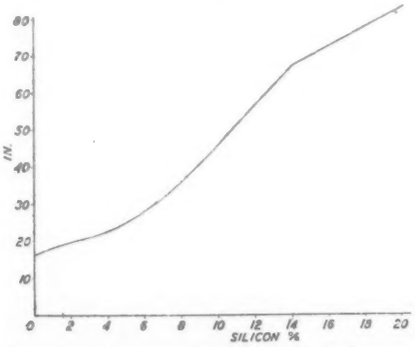


FIG. 14.—FLUIDITY CURVE OF IRON-SILICON ALLOYS CONTAINING 0.40 PER CENT. OF CARBON AT 1,600 DEG. C.

1.8 per cent. of carbon is reached, but there is a marked break in the curve at 0.71 per cent. of carbon. This corresponds with the end of the peritectic range, within which the delta-gamma system has to be considered, and after which the gamma system only. It would appear, therefore, that the results obtained by the fluidity tests clearly support the view that in the iron-carbon series of alloys two entirely separate systems have to be dealt with. As soon as the influence of the peritectic range is passed, that is, at 0.70 per cent. carbon, a perfectly straight-forward system occurs, where the fluidity of the alloy is inversely proportional to the liquidus-solidus range in the diagram. It has been shown that the eutectic

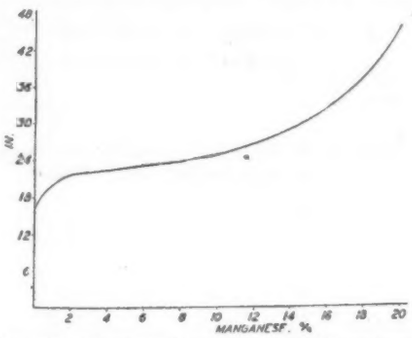


FIG. 15.—FLUIDITY CURVE OF IRON-MANGANESE ALLOYS CONTAINING 0.50 PER CENT. OF CARBON AT 1,600 DEG. C.

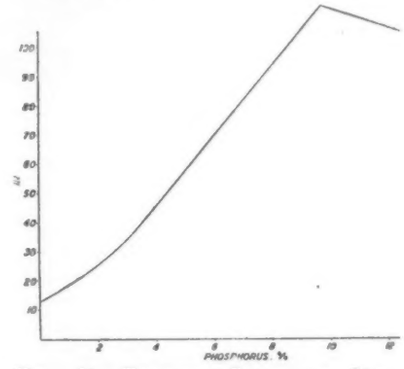


FIG. 16.—FLUIDITY CURVE OF IRON-PHOSPHORUS ALLOYS AT 1,600 DEG. C.

alloy is the most fluid of all, and therefore when the carbon content is increased beyond 1.8 per cent., and even when the casting temperature is only just above the solidus, the eutectic present

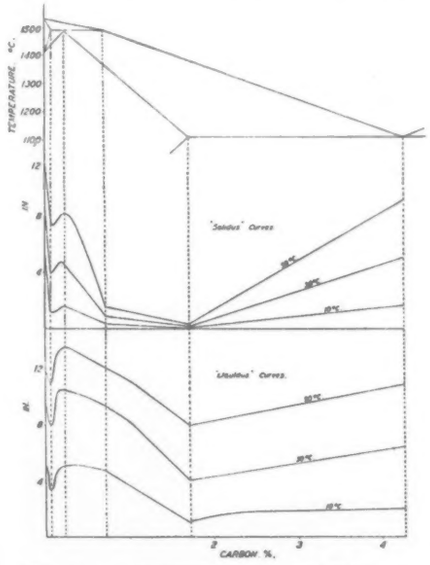


FIG. 17.—CONSTITUTIONAL DIAGRAM OF IRON-CARBON ALLOYS AND FLUIDITY CURVES AT 10 DEG., 30 DEG. AND 50 DEG. C. ABOVE THE LIQUIDUS AND SOLIDUS.

is sufficiently fluid to cause flow to some considerable extent. Naturally, as the amount of eutectic is increased the amount of flow will be correspondingly greater. In other words, the

amount of eutectic present governs the amount of flow in this range. Hence, it will be seen that while the degree of superheat, or the casting temperature, has an important bearing on the fluidity of an alloy, it is by no means the sole controlling factor. The structure of the alloy, possibly before, and certainly during

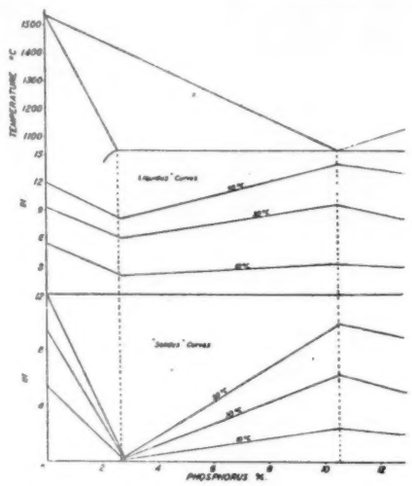


FIG. 18.—CONSTITUTIONAL DIAGRAM OF IRON-PHOSPHORUS ALLOYS, AND FLUIDITY CURVES AT 10 DEG., 30 DEG. AND 50 DEG. C. ABOVE THE LIQUIDUS AND SOLIDUS.

solidification, plays a very important part, and it now seems possible to forecast the comparative fluidity of an alloy of iron and carbon from its equilibrium diagram.

The same explanation may be applied to the iron-phosphorus series, shown in Fig. 18. The fluidity decreases with increase of phosphorus content to a minimum at 2.6 per cent. of phosphorus, at which point the eutectic range commences. The fluidity curve shows a maximum value at the eutectic composition.

In these experiments the alloys were sometimes cast as much as 400 deg. C. above their melting

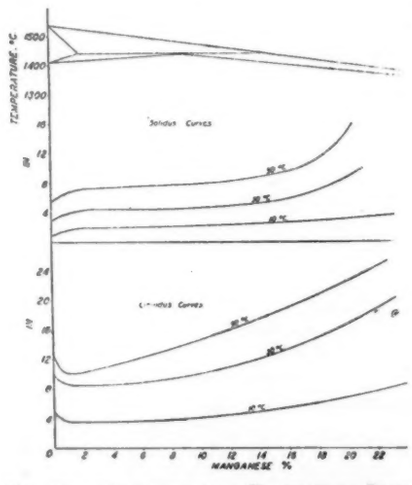


FIG. 19.—CONSTITUTIONAL DIAGRAM OF IRON-MANGANESE ALLOYS, AND FLUIDITY CURVES OF IRON-MANGANESE ALLOYS CONTAINING 0.50 PER CENT. OF CARBON AT 10 DEG., 30 DEG. AND 50 DEG. ABOVE THE LIQUIDUS AND SOLIDUS.

points, and the values for fluidity at, say, 10 deg. C. above the melting points, were obtained from temperature/fluidity curves. It is probable that the values given are higher than would be actually obtained if the alloys were cast at 10 deg. C. above their melting points, owing to the heating up of the mould with the high casting temperature, and the presence, therefore, of less chilling action.

The data relating to the iron-manganese series are incomplete at present. The curves are shown in Fig. 19. These alloys contain carbon, and the equilibrium diagrams available relate only to carbonless alloys. It is proposed to determine the thermal data on the alloys dealt with, but the indications are that the same interpretations will hold good. This also applies to the iron-silicon series of alloys, and discussion on these results is held over until more experimental data are obtained.

(To be continued.)

Book Review

Engineering Alloys: Names, Properties and Uses. By Norman E. Woldman, Ph.D., and Albert J. Dornblatt, Ch.E. Published by the American Society of Metals, 7016, Euclid Avenue, Cleveland, Ohio, U.S.A. Price 10 dollars.

We have only one criticism to make against this extraordinarily complete reference book, namely, that whilst so much work has been done in amassing such large quantities of data, an effort might have been made to correlate the various alloys with the patent situation. As our readers are aware, this has been done for certain groups of alloys by German workers.

The book is divided into seven sections, excluding a centrally-placed advertisement inset running to 54 pages. The first section lists alphabetically over 8,000 alloys, each one of which carries a serial number. In Section II the alloys are listed by the serial number and information is given under the following headings: Alloy (that is the trade mark name or official specification number); manufacturer's reference number; reference number to the published source of information; chemical composition; (heat) treatment; tensile strength; yield point; elongation; reduction of area; Brinell number, and uses and remarks.

Section III is—to quote the introduction—"primarily a grouping of alloys classified according to the uses listed in Section II." This makes the book really useful. For instance, if a manufacturer were seeking heat-resistant alloys, he would find two columns of references in Section II where, as mentioned above, the physical properties and chemical compositions are revealed.

Section IV is a directory wherein the manufacturers (and their American agents, if any) are listed alphabetically, together with the names of their branded alloys, and, of course, the reference number for tracing back to Section II. The United Kingdom entries are particularly prolific; for instance, Edgar Allen & Company have sixty-two entries, and those of Thos. Firth & John Brown must double this figure.

Section V helps a little more by listing the manufacturers' names and a reference number to the previous section, whilst Section VI contains a bibliography, which states the source of information upon which Section II is based.

Section VII is a collection of three appendices. The first is essentially useful as an attempt has been made to classify the alloys according to their published compositions. For instance, the well-known 12 per cent. silicon acid-resisting cast iron has nine references back to Section II. The second appendix is a collection of definitions, whilst the balance of the book is devoted to the physical constants of the principal alloy-forming elements and similar useful data.

The book is excellent in every way and has made a complete survey of the existing knowledge (or at least indicates the source of such information) of alloy compositions and properties. We fail to see how any manufacturer can afford not to have such information readily available. Sincere congratulations are offered to the compilers and the sponsoring society.

Impact Tests

The Institution of Mechanical Engineers has published a Paper on "The Correlation of Impact Tests, and the Problem of Standardisation," by MR. E. J. WARLOW-DAVIES and PROF. R. V. SOUTHWELL. The following is a summary.

It appears that more consistent and reliable results can be obtained from the Oxford impact testing machine and specimen, for the reason that "stray losses" have been eliminated from the energy account, and from the new specimen and method of loading, because only normal stresses act across the plane of fracture, and plastic distortion is confined to a narrow region immediately adjoining that plane. The energy of fracture is found to be closely proportional to the area of fracture. Hence the Oxford specimen (besides being much cheaper, since all machining is done in the lathe) appears to obviate most of the difficulties which have so far confronted attempts towards international standardisation.

But the practical objection to a change of standards will remain unless it can be shown that the same "impact property" of a material is measured in the Oxford as in (*e.g.*) the Izod test. Accordingly tests have been made on 21 materials of widely-different types, and the results are given in the Paper. They show clearly that the Izod and Oxford impact figures are closely proportional to one another over the whole range (from about 50 to 900 ft.-lbs. per sq. in.) of the tests. Hence it can be asserted with some confidence that the Oxford specimen and method of loading could be standardised without fear of wasting the experience gained hitherto from Izod tests. The case for such standardisation rests on the low cost of manufacture of the Oxford specimen, and on the consistency and dimensional simplicity of the results obtained by its use.

Some Factors Influencing the Production of Sound Castings

(Concluded from page 376.)

placed in contact with ammonia need hardly be emphasised.

Figs. 19 and 20 are photomicrographs of sections taken from castings similar to the large table illustrated in Fig. 2. Iron with the type of graphite, shown in Fig. 19, has all the properties desired and gives a steel-like appearance after machining. The casting was rejected because of slag inclusions on the top face.

Fig. 20 shows a section taken from a similar casting rejected for openness of grain and a poor appearance after machining. The manganese content of the first casting was 0.7 per cent. and in the second 1.10 per cent. The percentage of other elements was almost the same. It was experiences such as this which really led to this investigation. It is considered that there is still a great deal of work to be done on the effect of manganese on grey cast iron, and it is hoped at some later date to give results of further experiments using different base irons.

Acknowledgments

The authors wish to record their indebtedness to the directors of the Audley Engineering Company, Limited, for permission to publish this Paper, and for use of the company's equipment and materials. Also to those members of the staff of the Audley Engineering Company who have in any way helped towards the production of this Paper.

THE LOWEST of the ten tenders for the construction of the Samanond Bridge over the Nile, says a Cairo message, is £151,293 from Krupps, the German firm, and the lowest British tender is £171,796 from Dorman, Long & Company, Limited, Middlesbrough.

Sheffield and East Midlands Foundrymen Foregather

WORKS VISIT AND LECTURE

The East Midlands and Sheffield Branches of the Institute of British Foundrymen held a joint meeting in Derby on October 31. In the afternoon a party of about 130 members visited the works of International Combustion, Limited, where they were received by Mr. F. Gudgeon (works manager) and other members of the staff. The entire works was inspected by the visitors, including plate shops, machine shops, laboratories and foundries, and at the conclusion of the tour they were entertained to tea in the canteen.

MR. H. BUNTING (President of East Midlands Branch), proposing a vote of thanks to the hosts, and to the staff, said the visitors had seen that afternoon much that was not only interesting, but of an educational value. Since they last visited the works, as a Branch, ten years ago, the firm had made great progress, and was in the forefront in its particular industry. Mr. Bunting expressed the thanks of the members to International Combustion, Limited, and also to Mr. Gudgeon and the staff, who had given up the afternoon to make the visit interesting.

MR. J. ROXBURGH (President of the Sheffield Branch), in seconding the vote of thanks, said that the large attendance was very gratifying, and it must be a source of pleasure to the directors of International Combustion, Limited, to notice that they had taken advantage of the facilities that had been afforded to them that afternoon. It was always interesting for foundrymen to see another foundry's class of work, and to study the methods of production employed. The firm whose works they had just inspected was a very large organisation, and since their last visit it had developed wonderfully. He trusted that this successful development would continue.

MR. GUDGEON, responding on behalf of the firm, assured everyone that their visit had been a great pleasure. If they had been able to show anything that was new or interesting, they were glad for it to have been seen. Only by visiting other people's works were they able to see something that was slightly different from their own. Mr. Gudgeon said he had recently visited Germany. He had always thought that the Germans were paramount, but he could assure them that English foundry practice appeared to be superior to that of Germany. He, too, thanked the guides for their services that afternoon.

Technical Session

A technical session was held during the evening, under the chairmanship of Mr. Bunting, who expressed his appreciation of the attendance of their Sheffield friends at the joint meeting. These meetings, he said, had been held for many years, with only a few breaks, and he sincerely hoped that they would continue.

Mr. Bunting then called upon Mr. S. L. Ireland (Birmingham) to present a Paper on "Grinding Wheels in the Foundry."

MR. IRELAND gave an interesting address, illustrated by lantern slides and actual specimens. He outlined the history of the abrasive industry, and went on to explain how the manufacturers had experimented to produce abrasive wheels of greater life and safety than the natural abrasives. He then gave a *résumé* of the five methods of bonding the prepared abrasives, namely: (1) silicate of soda process, (2) shellac, (3) bakelite and resinoid, (4) rubber and (5), the most important of all, the ceramic or vitrified process. Samples were shown of the latest developments in the manufacture of "saw" grinding wheels and "honeycomb" discs, which are rapidly displacing the old type of abrasive-coated paper discs.

The lecturer also dealt with the many grades and grits of abrasive wheel which were available. As a general rule the shellac, rubber and bakelite-bonded wheels were numbered from 1 to 8 according to hardness, the No. 1 type being very soft and the No. 8 very hard. In vitrified and silicate bonded wheels an alphabetical code was used, commencing with the letter A, for very soft, and the end of the alphabet for very hard. Grain size was indicated by numerals from 10 to 200, 10 being very coarse and 200 very fine. For some special jobs wheels were made of varying grain sizes, the most common being known as the 24 combination.

Dealing with the use of grinding wheels, the Lecturer stressed the importance of maintaining the machines in good order. Vibration he described as the nightmare of the grinder. It was important that a wheel should be run at the speed recommended by the maker in order to be really efficient. As a wheel was worn to a smaller diameter, the speed of the machine required to be increased to attain the same peripheral feet per minute as when the wheel was new.

Mr. Ireland explained the correct and incorrect methods of mounting wheels on to machines, and advised everyone to test each wheel by "ringing" before fitting. This simple test was too often overlooked, and allowed of wheels, which were damaged before fixing, breaking under service. All wheels were thoroughly tested before despatch, and he advised everyone not to use a wheel which did not "ring" clearly. He demonstrated this with a sound and a cracked wheel.

DISCUSSION

MR. ROXBURGH thanked Mr. Bunting for the welcome which he had extended to the Sheffield members at the opening of the meeting. He was sure that they would all agree they had spent a very interesting day.

He congratulated Mr. Ireland on his excellent lecture. Grinding was a very wide subject, and the lecturer had done exceptionally well to cover it so ably. He was particularly interested in the reference to the use of the grinding wheel for grinding rolls. He asked whether, in the rough grinding of the chilled roll, they were able to develop rough grinding by segments to any great extent. It appeared that the manufacture of grinding wheels was definitely a very scientific matter, and he was sure that the research work that was being done would help them in the foundry.

MR. J. C. HALLAMORE said he would like Mr. Ireland to enlarge upon the point of wheels cracking, indicating to the foundrymen what precautions were taken to prevent the wheels breaking. With regard to diamonds for dressing a wheel, to a large extent they were not necessary, as ordinary cutters did the work almost as well.

MR. IRELAND said that the principal precaution to prevent a wheel breaking was that every care had to be taken in each different process that the wheel underwent. Nothing more could be done, but when the wheel was completed, there should be some method of testing it. Whilst the wheels were normally run at about 5,000 superficial feet per minute, they were tested by running on machines with specially constructed holders at over 9,000 superficial feet. He thought this test was sufficiently severe to reveal any faults. As to diamonds, he had said that, whilst they were usually used for a soft wheel, they were very rarely used for a hard wheel. The use of the ordinary dresser was quite sufficient for a hard wheel. A rectangular block, 6 in. by 2 in. square, made from very hard material, was useful for removing the face of a wheel which had glazed, but not of much use for dressing the wheel if it were out of shape. They did not use diamonds for foundry wheels.

MR. HALLAMORE asked whether, in moulding any of his wheels, Mr. Ireland used wire inserts to reinforce the wheel.

MR. IRELAND replied that the insertion of wire inside a wheel originated in the manufacture of silicate bonded wheels. In the vitrified wheels a wire ring would be useless, as it would melt during the vitrifying process.

A MEMBER asked for information of the "honeycomb" wheel for face-grinding castings. He had always understood that the better type was only for the patternshop. How would that wheel behave for castings?

MR. IRELAND said that a "honeycomb" disc, either small or large, would be much more rapid than the table type of machine. The disc must be reasonably used, and weight should not be applied on one portion of the disc. If the work were applied carefully and reasonably, a very true and accurate service was given.

MR. P. A. RUSSELL said he had heard a good deal about silicosis, and asked if Mr. Ireland could say whether any types of wheel had advantage in this respect. Was there hope of a grinding wheel ever being evolved which would not cause this trouble?

MR. IRELAND said there was no risk of silicosis from the grinding wheels as manufactured to-day. Silicosis was brought about by the silica in the bond of the wheel, and, as there was no free silica in the modern wheel, obviously the wheel could not cause the disease. Mr. Ireland emphasised the importance of running the wheel at the speed first recommended by the makers. A motor was needed to increase the speed as the wheels decreased in diameter, or it could be done by using geared pulleys. An ideal way was to have a series of machines; for instance, using a 12-in. wheel, the first machine would have clamp plates 10 in. diameter, so that when the wheel was worn down the plates would prevent further grinding, and the wheel would be moved to a second machine with 8-in. plates, and so on. In this way the wheel was kept up to speed and the wheel used to a very small diameter without waste.

MR. C. D. POLLARD said that in a foundry he previously managed, that method had been adopted, and proved to be most efficient. They had, as Mr. Ireland suggested, plates of certain diameters on machines. It was expensive to have more machines than one, but it proved an economical way of doing the job.

Vote of Thanks

MR. S. H. RUSSELL, proposing a vote of thanks, said that users of grinding wheels now had to work to very much finer limits. Mr. Ireland must have had considerable trouble in preparing the lecture; he had instructed them very much, and they realised the importance of the notes given.

MR. F. WHITEHOUSE seconded the vote of thanks, and Mr. Ireland suitably responded.

Kincardine-on-Forth Bridge

The Kincardine-on-Forth bridge, opened last week, was designed by Sir Alexander Gibb & Partners, of London, and the contractors for its construction were the Cleveland Bridge & Engineering Company, Limited, of Darlington. The total length is just over half a mile, and a roadway, 30 ft. wide, is constructed over the bridge, with two footpaths each 5 ft. wide, supported on a cantilever construction along each side of the main structure. One of the chief points of interest is the swing span in the centre of the bridge. This span rotates on a central pier, weighs 1,600 tons, and has a length of 364 ft., providing two clear openings for shipping, each 150 ft. wide. The whole of the control gear installed in this swing span, together with the traffic control, warning devices, etc., and the complete lighting of the bridge, was designed and manufactured by The General Electric Company, Limited.

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The Week's News in Brief

Trade Talk

MEMBERS of the Refractories Association of Great Britain visited the East Hecla Steelworks of Hadfields, Limited, Sheffield, recently.

GENERAL REFRACTORIES, LIMITED, have opened a new sales office, under the direction of Mr. Stanley G. Throssell, in the Manchester area.

STEWARTS AND LLOYDS, LIMITED, Glasgow, have received an order from the Buenos Aires Great Southern Railway for 4,400 solid drawn steel boiler tubes.

ALBION MOTORS, LIMITED, Scotstoun, Glasgow, and Frederick Braby & Company, Limited, Eclipse Works, Petershill Road, Glasgow, are to extend their works.

A BLAST FURNACE has been put into commission by the Sheepbridge Coal & Iron Company, Limited, at Chesterfield. The furnace will have an output of 1,000 tons a week.

THE FAIRFIELD SHIPBUILDING & ENGINEERING COMPANY, LIMITED, Govan, Glasgow, are to build a vessel for the Anchor Line for passenger and freight service between Bombay and Glasgow.

THE LONDON & NORTH EASTERN RAILWAY COMPANY, LIMITED, will construct 49 locomotives at their Darlington North Road Works in the near future. Several hundred carriages and wagons are also to be built.

THE FOUNDRY OF TURNBULL BROS., Crook, Co. Durham, which was started nearly 100 years ago, is being offered for sale. Last week the works were put up for auction, but no bid was obtained. The plant was closed down this year.

THE GRANGEMOUTH DOCKYARD COMPANY, LIMITED, have received an order from W. Holyman & Sons Proprietary, Limited, Launceston, Tasmania, for a general cargo motorship. The propelling machinery will be supplied by John G. Kincaid & Company, Limited, Greenock.

AN ARGEEMENT has been reached between William Denny & Bros., Limited, Leven Shipyard, Dumbarton, and Blackburn Aircraft, Limited, to build aircraft at Dumbarton. A new factory will be erected on ground belonging to Wm. Denny & Bros. near their shipyard and will be managed by them.

AT THE ANNUAL CONFERENCE of the Iron and Steel Confederation, held recently in Glasgow, it was stated that wages had increased in every section of the industry, and efforts towards more efficient organisation had been satisfactory. An address on the regulation of the production of iron and steel was given by Mr. James Walker, M.P.

HEAD, WRIGHTSON & COMPANY, LIMITED, of Stockton-on-Tees, were recently asked to replace the balustrade of an old cast-iron road bridge in County Durham which was ordered from them on June 23, 1870. Inquiries showed that the pattern was destroyed only five years ago, and a new pattern is now being made to the original drawings.

BLACKSTONE & COMPANY, LIMITED, engineers, of Stamford, Lincs, announce that they are introducing an efficiency bonus for their works employees, establishing a pension scheme, and forming a works committee, consisting of the directors of the company and four members of the staff nominated and elected by the employees, in anticipation of their centenary, which takes place next year.

DAVID BROWN & SONS (HUDDERSFIELD), LIMITED, have initiated a scheme to provide an annual scholarship tenable at Leeds University, which will enable apprentices to take a degree in mechanical engineering. Candidates will be selected from three classes of students :—(1) Boys who go to the works after matriculation and then do the matriculation apprenticeship course; (2) secondary school boys who have not matriculated at school, but do so during their first year at the works; and (3) boys from central and elementary schools and technical colleges who matriculate while taking the ordinary apprenticeship course. During University vacations students will return for practical experience at David Brown & Sons' works, and at the end of the degree course they will receive a final year's training at the works before competing with other graduates for suitable positions in the firm. This scheme, which has been compiled in conjunction with the Huddersfield Director of Education and the headmasters of local schools, is being supervised by the personnel manager, Dr. A. H. Seymour.

Personal

ALDERMAN JOSEPH TOOLE, of West End Ironworks, Middleton Road, Oldham, was elected Lord Mayor of Manchester on Monday.

MR. W. VINCENT WAITE has resigned his position of commercial manager with Davy Bros., Limited, Sheffield, after being with the company for five years.

DR. J. T. MACKENZIE, metallurgist and chief chemist of the American Cast Iron Pipe Company, Birmingham, Ala., has been appointed chairman of the Grey Cast Iron Division of the American Foundrymen's Association.

MR. G. C. USHER, managing director of International Combustion, Limited, Derby, has offered Derbyshire Royal Infirmary Saturday Fund Committee £350, if an equal amount can be raised by other supporters by the end of November.

MR. F. M. CHARLES, 83, Pall Mall, London, S.W.1, has been appointed as sole agent for the British Isles, Colonies and Dominions of Société des Etablissements a. Utard of Longeville en Barrois (Meuse), who specialise in modern foundry equipment of all kinds.

MR. E. H. SIDDALL has been appointed manager of the Dublin branch of Ruston & Hornsby, Limited, Lincoln, in succession to Mr. T. C. Ives. For the last seven years Mr. Siddall has been attached to the company's Glasgow branch. Mr. Ives is not severing his connection with the company.

THE STAFF of the patternmaking department of Glenfield & Kennedy, Limited, Kilmarnock, held a social function last week in honour of Mr. Alexander McCaw, who is retiring after 50 years' service with the firm. Mr. T. Greaves, the foreman, presided, and Mr. G. Rose made a presentation to Mr. Greaves.

MR. HORACE J. YOUNG has been appointed chief technical representative and metallurgist to the Sheepbridge Stokes Centrifugal Castings Company, Limited, Sheepbridge Works, Chesterfield. For fifteen years Mr. Young was chief metallurgist to the North Eastern Marine Engineering Company, Limited, of Wallsend-on-Tyne and Sunderland, leaving there to become a consultant in London. He then joined Hepworth & Grandage, Limited, of Bradford, from which firm he has now resigned to take up his present position.

Will

ELLISON, MAJOR W. R., of Weybridge, formerly works manager of Brown Bayley's Steel Works, Limited, Sheffield £14,553

Obituary

MR. JOHN VARLEY, principal of the engineering and ironfounding firm of Varley (Skipton), Limited, Skipton, died on October 30, at the age of 73.

MR. FRANCIS G. CHAMBERS, M.B.E., assistant to the locomotive works superintendent, at the London Midland & Scottish Railway chief mechanical engineer's department, Derby, died on November 5, at the age of 52.

MR. FRANK APPLEYARD, who died recently at the age of 51, was for 36 years connected with Davy Bros., Limited, of Sheffield, where he held the position of engineer and works manager. He later joined the staff of the Audley Engineering Company, Limited, Newport, Salop.

LIEUT.-COL. WALTER WILLIAM WIGGIN died on last week in his 81st year. Colonel Wiggin entered his father's business, that of Henry Wiggin & Company, Limited, of Birmingham, at the age of 22, ultimately becoming a director and finally chairman in 1916 on the death of his elder brother, Sir Henry A. Wiggin, Bt. He retired in 1920 when the business was merged with the Mond Nickel Company, Limited. He had served also as a director of Joseph Lucas, Limited, of W. & T. Avery, Limited, and as chairman of W. Hunt & Sons (The Brades), Limited. He was a Justice of the Peace for Staffordshire and Worcestershire.

Contracts Open

Chailey, November 16.—One mile of 4-in. dia. spun-iron pipes; half-mile of 3-in. dia. spun-iron pipes; cast-iron hydrant and valve covers and frames, for the Rural District Council. The Engineer and Surveyor, 31, High Street, Lewes.

Downham, November 20.—25 miles of 3-in. dia. cast-iron pipes and 18 miles of 4-in., 5-in., 6-in. and 7-in. dia. spun-iron pipes, for the Rural District Council. Mr. W. J. Hyner, clerk, Council Offices, Downham Market, Norfolk. (Fee £5, returnable.)

Dublin, November 16.—Iron and steel, for the Great Northern Railway (Ireland). Mr. F. C. Wallace, secretary, Amiens Street Station, Dublin.

Purleigh, November 16.—Six miles 78 yds. of 5-in., one mile 82 yds. of 4-in., and three miles 600 yds. of 3-in. dia. spun-iron pipes, for the Maldon Rural District Council. Mr. W. Almond, engineer, 6, Market Hill, Maldon, Essex.

Windsor, November 23.—Cast-iron pipes and specials; street ironwork, for the New Windsor Town Council. Mr. F. N. McRae, borough engineer, 16, Alma Road, Windsor.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Armstrong-Bentley, Limited, 70, Gracechurch Street, London, E.C.3.—Capital, £4,000. General engineers, metal founders, etc.

St. Peter's Foundry Company, Limited, Walker Road, Newcastle-upon-Tyne. — Capital, £2,500. Directors: W. Henderson, and W. Henderson, junr.

B. & F. Carter & Company, Limited, Albion Works, Whitehall Street, Rochdale.—Capital, £60,000. Iron, brass, and general metal founders, etc. Directors: Sir Ian S. Richardson, Bt., B. Carter, and E. Carter.

Company Reports

Richard Thomas & Company, Limited.—Interim dividend of 5 per cent.

International Nickel Company of Canada, Limited.—Dividend of 40 cents on the common stock.

British Oxygen Company, Limited.—Interim dividend on ordinary stock of 7 per cent. (or 1s. 4.8d. per £1 unit), on account of the year 1936.

John I. Thornycroft & Company, Limited.—Profit of £53,740, which, after meeting debenture interest, is sufficient to wipe out the standing debit of £33,463 and to carry forward a credit of £6,777.

Birmingham Small Arms Company, Limited.—Profit, £270,835; provision for 6 per cent. debenture interest, £73,724; sinking fund, £25,840; net balance, £171,271; brought in, £67,873; payment of five years' dividends on the "A" preference stock to July 31, 1936, £38,725; carried forward, £64,673.

Forthcoming Events

Institute of British Foundrymen

NOVEMBER 14

Scottish Branch :—"Mould and Core Washes at Atmospheric and Elevated Temperatures." Paper by R. F. Hudson, at the Royal Technical College, Glasgow, at 4 p.m.

Wales and Monmouth Branch :—"Some Technical Observations on the Production of Cast Iron," Paper by J. H. Williams, at the Technical College, Newport.

West Riding of Yorkshire Branch :—"Dimensional Tolerances for Castings with Particular Reference to Malleable Cast Iron," presented by F. K. Neath, B.Sc., at the Technical College, Bradford, at 6.30 p.m.

NOVEMBER 20.

Middlesbrough Branch :—Works visit to Cochranes (Middlesbrough) Foundry, Limited.

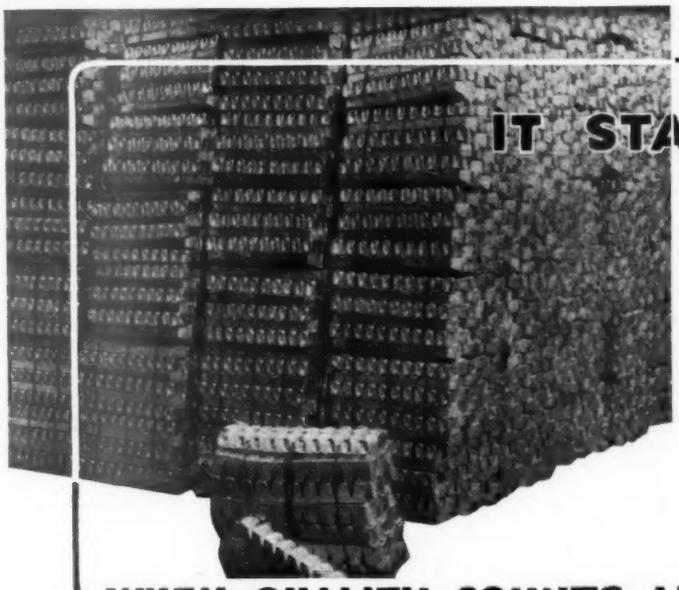
NOVEMBER 21.

Newcastle-upon-Tyne Branch :—"Estimating for the Foundry." Paper by C. M. White, at Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

The Institute of Vitreous Enamellers

NOVEMBER 19.

Midland Section :—"Application and Drying of Enamel Ware," Paper by P. G. Pickwell; Symposium on "Drying," opened by P. G. Pickwell and H. H. Macey, and the Chamber of Commerce, New Street, Birmingham, at 7.30 p.m.



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- Low Carbon Cylinder
(FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
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(FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

Typical Cylinder Pig Iron Specification

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

Typical Malleable Pig Iron Specification

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

WARNER & CO. LTD.
CARGO FLEET · MIDDLESBROUGH

Raw Material Markets

There is little change to report in the condition of the iron and steel industry. Chief activity concerns the maintenance of deliveries against existing contracts, and new business of any magnitude remains out of the question. Supplies of both foundry iron and hematite are difficult to negotiate except where already contracted for, and with many consumers in need of additional supplies, the position is very firm indeed. Prices of hematite are, as yet, unchanged, but producers are endeavouring to secure an increase in the standard rate.

Pig-Iron

MIDDLESBROUGH.—The rationing of all available supplies of pig-iron to users continues. Local steel furnaces are responsible for the consumption of the bulk of the output, and any surplus is soon cleared. Hopes are expressed that the output will be enlarged before the end of the year, but the increase will have to be considerable before there is any marked change in the conditions. Prices remain unaltered, but advances are expected before many months have passed. Current quotations are based on the standard No. 3 Cleveland G.M.B. grade at 75s. per ton in the Middlesbrough and Falkirk areas, 77s. on the North-East Coast, and 78s. on Clydeside.

The question of prices also dominates the market for hematite. Such factors as higher wages and dearer ore and coke have all contributed to the decision of makers to seek official sanction for the imposition of a 10s. per ton advance on current prices, which are based on East Coast mixed numbers at 85s. per ton, less 5s. rebate, for delivery on the North-East Coast.

LANCASHIRE.—Producers of pig-iron in this area are willing to transact business up to the end of June, and some heavy tonnages have recently been contracted for. Deliveries have been well maintained, and users continue to call for substantial tonnages against existing contracts. For delivery to users in the Lancashire price zone, Staffordshire and Derbyshire brands of No. 3 foundry iron are quoted on the basis of 83s. per ton, with Northants at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s., according to the class of consumer. Supplies of hematite in this district also are very short, and thus prices are more or less nominal at 93s. 6d. for West Coast and 93s. for East Coast material, both delivered equal to Manchester. Scottish No. 3 foundry, delivered to Manchester, is quoted around 93s. 6d. per ton.

MIDLANDS.—Local ironfounders are fully active and have heavy requirements of pig-iron. Supplies of Northamptonshire material are very stringent, and makers have sold their output of this grade up to the end of March. Derbyshire iron is available for delivery up to the end of June, and some good sales are reported. A meeting of the Central Pig-iron Producers' Association was held in London recently, but no changes in prices were made. The minimum Association figures are 77s. 6d. for Northants No. 3 and 80s. for Derbyshire, Lincolnshire and South Staffordshire No. 3, delivered Birmingham and Black Country stations, with 11d. per ton extra for delivery into works. These prices are subject to a small sliding-scale rebate to large consumers. A good demand exists for forge pig-iron at 5s. per ton below No. 3 foundry if used for puddling and 3s. less if used for foundry purposes. Special irons are moving into consumption in large tonnages. The light-castings founders are the chief users, but the general engineering, motor and jobbing trades are also responsible for the consumption of some heavy tonnages. Prices are as follow:—Medium-phosphorus iron, 82s. to 90s.; low-phosphorus, 92s. 6d. to 100s.; refined iron, £6 5s. to £6 7s. 6d. per ton, delivered the Midlands. There is little change to report in the condition of the hematite trade. Many furnaces are quite off the market, while others demand a premium for any business they transact. Deliveries against existing contracts have, in some cases, fallen behind schedule, and thus users have been seriously inconvenienced. Association prices are nominal and unchanged at £4 16s. for East Coast No. 3, £4 17s. for West Coast mixed numbers and £4 15s. 6d. for Welsh makes, delivered local stations, with 1s. 6d. extra if delivered into works.

SCOTLAND.—A strong demand, which fully accounts for the output, makes the market in this area display a very firm appearance. The light-castings works continue to be actively employed. No. 1 foundry is quoted at 81s. and No. 3 at 79s. f.o.t. furnaces. No. 3 Cleveland iron is at 75s. f.o.t. Falkirk and 78s. f.o.t Glasgow, but these figures are only nominal, as there is no material available Forge iron is well taken up by the malleable ironworks at 78s. f.o.t. Coatbridge. The steelworks have very substantial requirements of hematite at the following unchanged prices:—Mixed numbers of East Coast, West Coast and Scottish hematite, 85s. 6d., less 5s. rebate; basic, British and Indian, 75s., less 5s. rebate, all f.o.t. steelworks.

Coke

Prices on the foundry-coke market are without change. Most users have fully covered their winter's requirements, and thus any alteration would have no immediate effect on the market. For delivery in Birmingham and district, best Durham coke is quoted at between 40s. and 42s. 6d., with Welsh at 40s. up to 54s. per ton.

Steel

There has been no relaxation in the busy conditions which have ruled in the steel trade for many weeks, and the pressure exercised by consumers to obtain urgently needed material is a noticeable feature of the position, says the official report of the London Iron and Steel Exchange. In many cases plant has been working continuously for long periods, and the manufacturers would be glad if there were a lull in the demand to give an opportunity for an overhaul which is more than due. In most departments suppliers are concentrating upon meeting their contract commitments and are not seeking new business. In the semi-finished steel department stringent conditions still rule, but lately the situation has been eased by the importation of material from the Continent. The British works also are producing practically at capacity, but are unable to satisfy the full requirements of their customers. Operations in the finished steel section of the market show no decline from the high rate which has obtained for many weeks. In practically all departments the demand is in excess of the capacity of the producing works, and although efforts are being made by the makers to divide their outputs among consumers there is a tendency for delivery arrears against contracts to accumulate.

Scrap

Quotations display a rising tendency in the Cleveland area, and supplies are easily disposed of. There is a very strong inquiry for heavy steel scrap at 60s. per ton, while heavy tonnages of machinery cast-iron scrap at 67s. 6d. and heavy foundry metal at 65s. have changed hands. The Midland market is steady, and all qualities receive attention. Firm prices are quoted. Heavy steel in furnace sizes is at 53s. 6d., which is also quoted for mixed iron and steel. Cast-iron scrap is well taken up by local ironfounders, with heavy machinery, broken into cupola sizes, at 72s. 6d., good heavy pipe and plate at 67s. 6d., and clean light at 55s. Short, heavy steel scrap, suitable for foundry purposes, is at 65s. to 67s. 6d. per ton, delivered works. The turnover in scrap material on the Scottish market is on a heavy scale. Supplies of foreign scrap have decreased recently. First-quality heavy steel scrap is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, at 5s. less. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is 69s. to 70s., and heavy ordinary cast-iron scrap, to the same specification, is 64s. to 65s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—A further increase in production has been announced by producers taking part in the world control scheme. The latest advance is of 10 per cent. of standard, which raises the output quotas to 105 per cent. This decision became effective on November 5. To say that the market was surprised is to put it mildly, for only five days before had an increase been announced. Buying has again been very heavy, and at the present time, the electrical, building, engineering and other industries have expanding requirements. The armament firms also are taking up substantial tonnages. The general opinion appears to be that with a control scheme not allowing output to be varied at very short notice the price of copper would undoubtedly have been forced to higher levels.

Daily market prices:—

Cash.—Thursday, £44 2s. 6d. to £44 5s.; Friday, £44 13s. 9d. to £44 15s.; Monday, £44 6s. 3d. to £44 7s. 6d.; Tuesday, £43 17s. 6d. to £44; Wednesday, £43 11s. 3d. to £43 13s. 9d.

Three Months.—Thursday, £44 8s. 9d. to £44 10s.; Friday, £45 1s. 3d. to £45 2s. 6d.; Monday, £44 13s. 9d. to £44 15s.; Tuesday, £44 6s. 3d. to £44 7s. 6d.; Wednesday, £43 18s. 9d. to £44 1s. 3d.

Tin.—At the meeting of the International Tin Committee in Paris on Thursday, November 5, a new agreement regarding international tin control was reached. It is stated that agreement has been arrived at between the Siamese and other delegates regarding the tonnage basis on which Siam becomes a party to the renewal of tin control. The agreement will be submitted for the approval of the Governments concerned. The next meeting of the International Tin Committee will be held in London on December 11. It is further reported that the agreement provides for the maintenance of control over the production and export of tin for five years after the expiration of the present scheme, and that standard tonnages have been agreed upon, giving a total standard production of approximately 197,000 tons. After a decline of £3 5s. on Thursday the price of standard metal rose £21 15s. to £235 10s. on Friday. These figures are the highest reached for twelve months. Tin shares on the London Stock Exchange have shown some spectacular advances in price. The position is summed up in one report as "brokers scrambling to execute orders in a market which was 'all buyers.'" However, maintaining its reputation for violent fluctuations, the price of spot metal dropped £12 10s. on Wednesday following the receipt of the news that the International Tin Regulation Committee had increased the output quota from 90 per cent. to 105 per cent., retrospective to October 1.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £213 15s. to £214; Friday, £235 10s. to £236; Monday, £240 5s. to £240 10s.; Tuesday, £244 10s. to £244 15s.; Wednesday, £232 to £232 10s.

Three Months.—Thursday, £210 10s. to £211; Friday, £232 10s. to £233; Monday, £238 to £238 5s.; Tuesday, £241 10s. to £241 15s.; Wednesday, £228 15s. to £229 5s.

Spelter.—This market reacted in sympathy with other metals, and the tone has been firm. The position would appear to be somewhat artificial, however. Rolled zinc is in heavy demand in the United States, where the market is very active.

Official quotations were as follow:—

Ordinary.—Thursday, £16 1s. 3d.; Friday, £16 8s. 9d.; Monday, £16 6s. 3d.; Tuesday, £16 6s. 3d.; Wednesday, £16 1s. 3d.

Lead.—Encouraged by the very heavy requirements of the cable industry other consumers have bought freely in this market. Consumption is heavy and is rapidly increasing.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £20 11s. 3d.; Friday, £21 6s. 3d.; Monday, £21 8s. 9d.; Tuesday, £21 2s. 6d.; Wednesday, £21 5s.

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SAND/SHOT BLAST PLANT

consisting of two barrels 30 in. diameter x 18 in. wide, two-jet apparatus for working the barrels, horizontal totally enclosed Tilghman air compressor, air receiver and exhaust fan. This plant can be seen at work in the Midlands

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R. J. RICHARDSON & SONS, LTD,
Commercial Street, Birmingham

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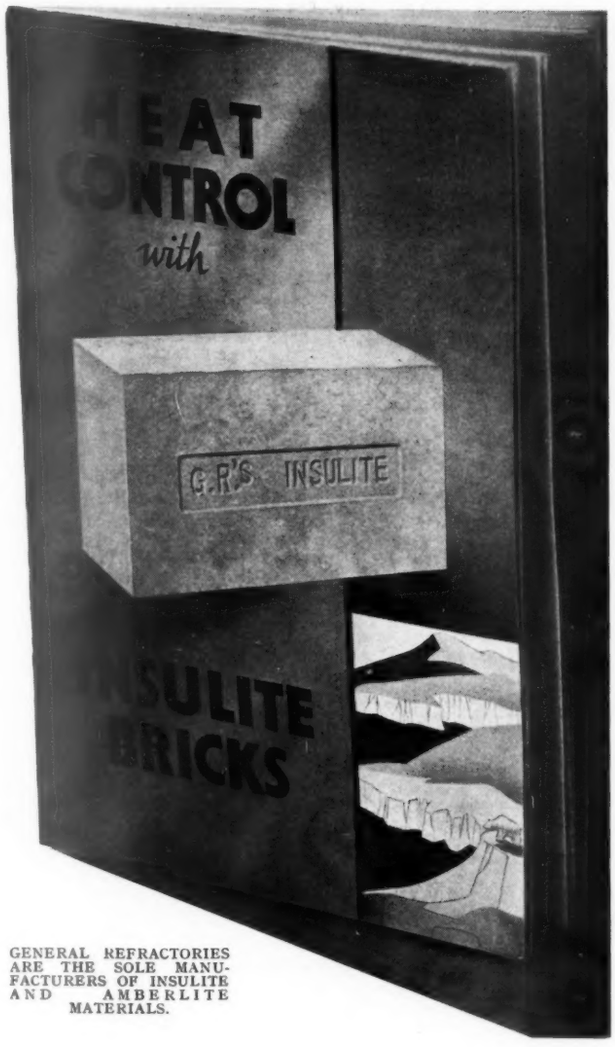

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MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, November 11, 1936)

COPPER

	£ s. d.
Standard cash	43 11 3
Three months	43 18 9
Electrolytic	48 10 0
Tough	47 15 0
Best selected	48 5 0
Sheets	78 0 0
India	58 10 0
Wire bars	49 10 0
Ingot bars	49 10 0
H.C. wire rods	53 0 0
Off. av. cash, Oct.	41 0 4 2/4
Do., 3 mths., Oct.	41 3 10 1/4
Do., Sttlmnt., Oct.	41 0 5 3/4
Do., Electro, Oct.	45 10 6 3/4
Do., B.S., Oct.	45 0 10
Do., wire bars, Oct.	45 15 1 1/4
Solid drawn tubes	11¾d.
Brazed tubes	11¾d.
Wire	7¼d.

BRASS

Solid drawn tubes	10½d.
Brazed tubes	12½d.
Rods, drawn	9½d.
Rods, extd. or rlld.	5¾d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	8½d.
Yellow metal rods	5½d.

TIN

	£ s. d.
Standard cash	232 0 0
Three months	228 15 0
English	232 10 0
Bars	234 0 0
Straits	234 5 0
Australian	232 0 0
Eastern	233 2 6
Banca (nom.)	234 0 0
Off. av. cash, Oct.	201 7 3 3/11
Do., 3 mths., Oct.	199 2 0 6/11
Do., Sttlmt., Oct.	201 6 9 9/11

SPELTER

	£ s. d.
Ordinary	16 1 3
Remelted	15 0 0
Hard	14 0 0
Electro 99.9	18 1 3
English	17 2 6
India	15 0 0
Zinc dust	19 15 0
Zinc ashes	4 10 0
Off. aver., Oct.	14 13 10 3/4
Aver. spot, Oct.	14 11 0 1/2

LEAD

	£ s. d.
Soft foreign ppt.	21 5 0
Empire	21 17 6
English	23 5 0
Off. aver., Oct.	18 8 2 3/4
Aver. spot, Oct.	18 8 11 1/2

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	25 10 0 to 26 0 0
Do., V.M. ex-whse.	25 10 0 to 26 0 0
Rods	28 0 0

ANTIMONY

	£ s. d.
English	67 10 0 to 68 10 0
Chinese, ex-whse.	52 0 0
Crude, c.i.f.	25 5 0

QUICKSILVER

	£ s. d.
Quicksilver	14 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	11 0 0 to 12 5 0
75%	16 2 6 to 17 7 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/1½ lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.5% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 15 0 to 12 5 0
76/80% packed	£12 15 0 to 13 5 0
76/80% export	£10 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales—	£ s. d.	£ s. d.
Heavy steel		3 4 0
Mixed iron and steel	3 0 0	to 3 1 0
Heavy cast iron	2 18 0	to 3 0 0
Good machinery	3 2 6	to 3 5 0
Cleveland—		
Heavy steel		3 0 0
Steel turnings		2 5 0
Heavy cast iron		3 5 0
Heavy machinery		3 7 6
Midlands—		
Light cast-iron scrap		2 15 0
Heavy wrought iron	3 5 0	to 3 7 6
Steel turnings		2 0 0
Scotland—		
Heavy steel		2 17 6
Ordinary cast iron	3 4 0	to 3 5 0
Engineers' turnings		2 2 6
Cast-iron borings		1 18 0
Wrot-iron piling		3 10 0
Heavy machinery	3 9 0	to 3 10 0

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	37 0 0
Brass	23 0 0
Lead (less usual draft)	20 10 0
Tea lead	18 0 0
Zinc	9 10 0
New aluminium cuttings	74 0 0
Braziery copper	34 0 0
Gunmetal	35 0 0
Hollow pewter	165 0 0
Shaped black pewter	120 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/-
,, No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
,, No. 3 fdry.	80/-
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/-
,, fdry. No. 3	80/-
,, fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
,, ,, Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	93/6
Clyde, No. 3	93/6
Monkland, No. 3	93/6
Summerlee, No. 3	93/6
Eglinton, No. 3	93/6
Gartsherrie, No. 3	93/6
Shotts, No. 3	93/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)		10 10 0
Nut and bolt iron	8 17 6	to 9 7 6
Hoops	11 7 6	and up.
Marked bars (Staffs) f.o.t.		13 0 0
Gas strip	11 7 6	and up.
Bolts and nuts, ¾ in. × 4 in.		16 0 0 and up.
Steel—		
Plates, ship, etc.	9 7 6	to 9 10 0
Boiler plts.	9 17 6	to 10 0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5½ in.		10 0 0
Rounds under 3 in. to ⅜ in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
,, under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		12 0 0
Galv. cor. shts. (,,)		14 0 0
Galv. flat shts. (,,)		14 10 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6
Billets, hard	7 2 6	to 7 7 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	13½d.
Rods	12½d.
Tubes	14½d.
Castings	12½d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	32.00
Sheet bars	32.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	2.05
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.60
Sheets, galv., No. 24	3.20
Wire nails	2.05
Plain wire	2.50
Barbed wire, galv.	2.55
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 32/-
,, furnace	24/6 to 25/-
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	18/9
,, 28×20 ,,	37/6
,, 20×10 ,,	26/9 to 27/-
,, 18¾×14 ,,	19/6
C.W. 20×14 ,,	15/6 to 15/9
,, 28×20 ,,	33/9 to 34/-
,, 20×10 ,,	22/6 to 22/9
,, 18⅞×14 ,,	15/3 to 15/9

SWEDISH CHARCOAL IRON & STEEL

	£ s. d.	£ s. d.
Pig-iron	6 0 0	to £7 0 0
Bars-hammered, basis	£16 0 0	to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0	to £16 0 0
Blooms	£10 0 0	to £12 0 0
Keg steel	£25 0 0	to £28 0 0
Faggot steel	£18 0 0	to £23 0 0
Bars and rods dead soft, st'l	£10 0 0	to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Nov. 5 ..	44 2 6 dec.	2/6
,, 6 ..	44 13 9 inc.	11/3
,, 9 ..	44 6 3 dec.	7/6
,, 10 ..	43 17 6 ,,	8/9
,, 11 ..	43 11 3 ,,	6/3

Electrolytic Copper

	£ s. d.	
Nov. 5 ..	48 15 0 inc.	5/-
,, 6 ..	49 5 0 ,,	10/-
,, 9 ..	49 10 0 ,,	5/-
,, 10 ..	48 15 0 dec.	15/-
,, 11 ..	48 10 0 ,,	5/-

Standard Tin (cash)

	£ s. d.		
Nov. 5 ..	213 15 0 dec.	65/-	
,, 6 ..	235 10 0 inc.	435/-	
,, 9 ..	240 5 0 ,,	95/-	
,, 10 ..	244 10 0 ,,	85/-	
,, 11 ..	232 0 0 dec.	250/-	

Tin (English ingots)

	£ s. d.		
Nov. 5 ..	214 0 0 dec.	70/-	
,, 6 ..	235 10 0 inc.	430/-	
,, 9 ..	240 10 0 ,,	100/-	
,, 10 ..	244 10 0 ,,	80/-	
,, 11 ..	232 10 0 dec.	240/-	

Spelter (ordinary)

	£ s. d.		
Nov. 5 ..	16 1 3 dec.	3/9	
,, 6 ..	16 8 9 inc.	7/6	
,, 9 ..	16 6 3 dec.	2/6	
,, 10 ..	16 6 3 No	change	
,, 11 ..	16 1 3 dec.	5/-	

Spelter (Electro, 99.9 per cent.)

	£ s. d.		
Nov. 5 ..	18 1 3 dec.	3/9	
,, 6 ..	18 10 0 inc.	8/9	
,, 9 ..	18 6 3 dec.	3/9	
,, 10 ..	18 6 3 No	change	
,, 11 ..	18 1 3 dec.	5/-	

Lead (soft foreign, prompt)

	£ s. d.		
Nov. 5 ..	20 11 3 inc.	6/3	
,, 6 ..	21 6 3 ,,	15/-	
,, 9 ..	21 8 9 ,,	2/6	
,, 10 ..	21 2 6 dec.	6/3	
,, 11 ..	21 5 0 inc.	2/6	

Lead (English)

	£ s. d.		
Nov. 5 ..	22 10 0 inc.	5/-	
,, 6 ..	23 10 0 ,,	20/-	
,, 9 ..	23 10 0 No	change	
,, 10 ..	23 5 0 dec.	5/-	
,, 11 ..	23 5 0 No	change	

AVERAGE MONTHLY PRICES OF STEEL BOILER PLATES IN ENGLAND

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1899	7 5 0	8 0 0	8 2 6	8 2 6	8 5 0	8 5 0	8 12 6	8 12 6	8 15 0	8 15 0	9 2 6	9 5 0	8 17 8½
1900	9 5 0	9 5 0	9 7 6	9 10 0	9 12 6	10 5 0	10 5 0	10 5 0	10 5 0	10 0 0	9 15 0	9 15 0	9 15 10
1901	9 5 0	9 5 0	8 15 0	8 10 0	8 10 0	7 10 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 3 11
1902	7 7 6	7 0 0	7 12 6	7 12 6	7 12 6	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 9 7
1903	7 10 0	7 10 0	7 15 0	7 5 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 3 11½
1904	6 12 6	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 11½
1905	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 10 0	7 5 0	8 0 0	8 0 0	7 1 3
1906	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 0 10
1907	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 8 4
1908	7 10 0	7 10 0	7 10 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 3 9
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 15 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 9
1910	7 0 0	7 0 0	7 1 3	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 10 0	7 10 0	7 10 0	7 5 1
1911	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 14 0	7 10 4
1912	7 18 9	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 15 0	8 16 3	9 0 0	9 2 0	9 5 0	8 11 2½
1913	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	8 19 0	8 15 0	8 5 0	7 15 0	7 15 0	8 17 0
1914	7 15 0	7 15 0	7 15 0	7 13 9	7 10 6	7 5 0	7 0 0	8 0 0	8 2 6	8 5 0	8 5 0	8 5 0	7 15 11½
1915	8 14 0	9 10 0	9 17 6	10 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 4 0	12 0 0	13 0 0	10 15 5½
1916	13 0 0	13 0 0	13 0 0	12 15 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 12 11
1917	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1918	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1919	13 0 0	15 0 0	15 0 0	15 0 0	19 5 0	19 17 6	21 0 0	21 10 0	21 10 0	21 10 0	21 15 0	23 10 0	18 9 9
1920	26 0 0	28 0 0	28 5 0	28 10 0	29 5 0	30 0 0	30 0 0	30 0 0	30 10 0	31 0 0	31 0 0	31 0 0	29 9 2
1921	30 5 0	29 0 0	25 0 0	25 0 0	25 0 0	23 0 0	21 0 0	20 10 0	19 0 0	17 10 0	16 0 0	14 16 0	22 1 9
1922	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 1 8	13 10 0	12 15 0	12 10 0	12 10 0	12 10 0	12 6 0	13 10 9
1923	12 8 9	13 6 0	14 0 0	14 0 0	14 0 0	14 0 0	13 12 6	13 0 0	13 0 0	13 0 0	13 0 0	13 10 0	13 9 1½
1924	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	14 0 0	14 0 0	13 11 0	13 5 0	13 5 0	13 10 11
1925	13 5 0	13 5 0	13 5 0	13 1 0	12 15 0	12 15 0	12 15 0	12 15 0	12 7 6	11 14 0	11 10 0	11 10 0	12 11 5½
1926	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 6 3
1927	11 5 0	11 5 0	11 5 0	11 5 0	11 2 6	11 0 0	11 0 0	11 0 0	10 16 0	10 10 0	10 10 0	10 10 0	10 19 0½
1928	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0
1929	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 5 0	10 1 3	10 1 3	10 1 3	10 1 7	10 6 8½
1930	10 2 9	10 3 5½	10 3 9	10 3 9	10 3 6	10 2 6	10 2 6	10 2 6	10 2 2½	9 19 6	9 16 3	9 16 3	10 1 6½
1931	9 15 0	9 15 0	9 15 0	9 10 11	9 6 9	9 5 0	9 7 0	9 7 9½	9 8 9	9 5 9	9 5 6	9 9 6	9 9 4
1932	9 5 0	9 2 6	8 18 6	8 17 6	8 16 6½	8 16 3	8 16 3	8 16 3	8 16 3	8 16 3	8 16 3	8 16 3	8 17 10
1933	8 10 0	8 10 0	8 10 0	8 8 9	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 6 0	8 7 6	8 6 10½
1934	8 8 1½	8 10 7½	8 16 6	8 17 6	8 6 3	8 6 3	8 5 7½	8 5 0	8 5 0	8 5 0	9 6 3	9 6 3	8 11 5½
1935	9 6 3	9 6 3	9 6 3	9 6 3	9 6 2	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3
1936	9 6 3	9 6 3	9 6 3	9 6 3	9 9 4½	9 18 9	9 18 9	9 18 9	9 18 9	9 18 9	—	—	—

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